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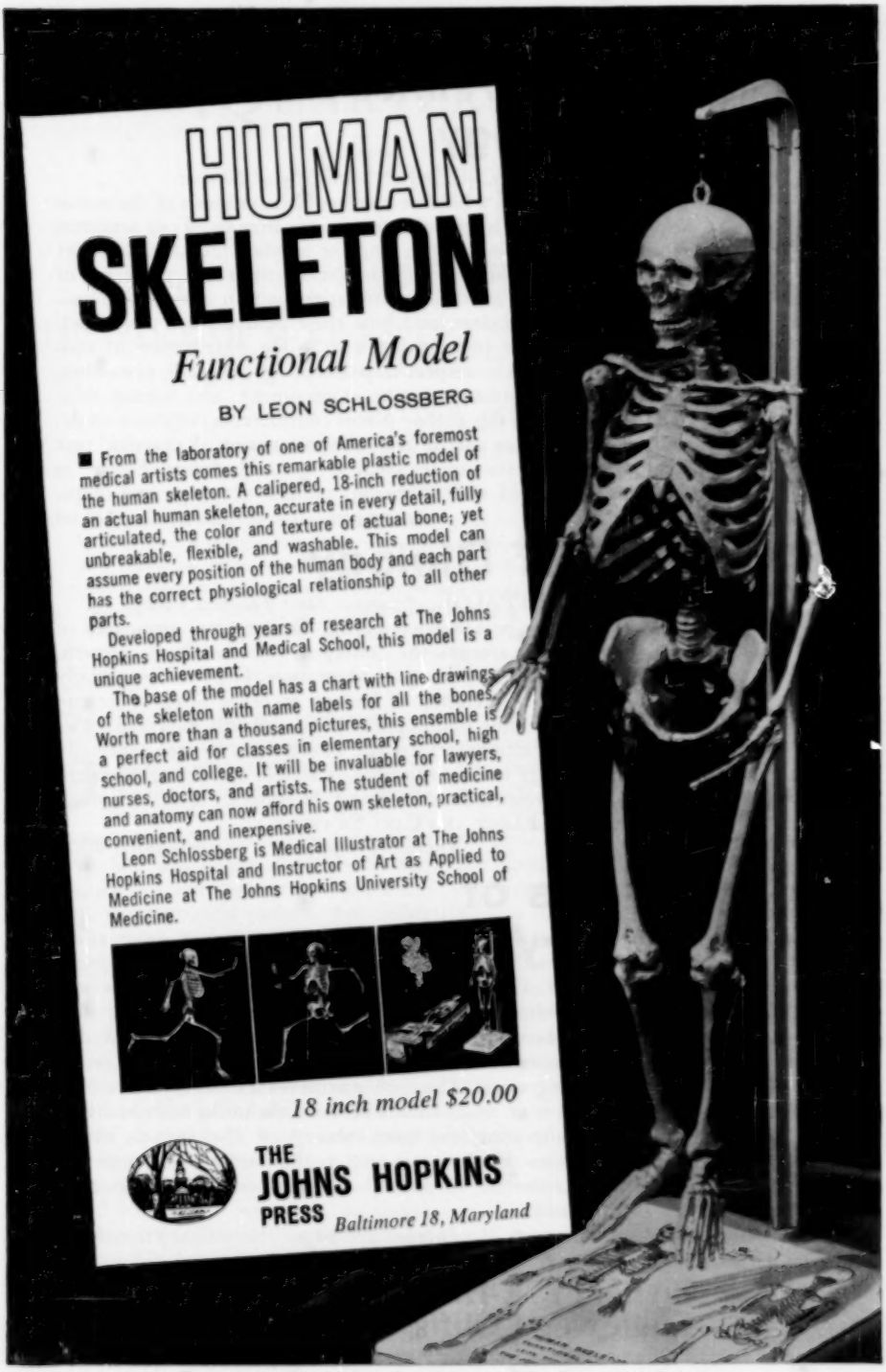

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THE QUARTERLY REVIEW of BIOLOGY

THE ROLE OF MODERN CULTURE METHODS IN THE STUDY OF ALGAL LIFE CYCLES

BY ANNETTE W. COLEMAN

Department of Biology and McCollum Pratt Institute, The Johns Hopkins University, Baltimore

ABSTRACT

Information on the experimental control of the phenomena of zoospore and gamete formation are summarized along with current theories of their underlying physiology. No theory has yet been proposed which satisfactorily incorporates all the data available on the effects of light, temperature, carbon dioxide, oxygen, and external nutrients. Algal culture methods should profit from the adoption of synchronizing techniques now available for algae, and physiological studies of altered cell development should examine more thoroughly the roles of trace elements, vitamins and hormones, red in contrast to far-red light, and the biochemical changes in cell composition during growth.

GROWTH and cell replication are the sine qua non of living organisms. Both processes are essential to the maintenance of any species above the level of the viruses; yet only recently has experimental evidence been presented which suggests that these fundamental life processes may actually represent not a single, cyclic developmental pathway but rather two simultaneously occurring pathways, more or less independent of each other, whose points of interaction may be manipulated experimentally. Thus, Scherbaum and Zeuthen (1954) were able, by means of repeated heat shocks, to block cell division in *Tetrahymena* while growth continued. When the shock treatment was discontinued, a rapid series of cell divisions occurred, reducing the giant cells to many small daughters, while growth lagged far behind. The usually constant relationship observed between cell growth and cell division was upset, indicating that constancy is not necessarily a characteristic of the relationship, but rather that two pathways occur at the same time in the cell, one leading to cell growth and one leading to cell division. The interaction between these two pathways, which leads to cell replication at a nearly constant maximum cell size, is one of the prime current concerns in research with protozoa (Prescott, 1957).

Similar investigations are just beginning in the algae, and so far they but serve to reinforce the conclusions of the protozoologists. It seems only reasonable that all cells carry on at least the two major biological processes of cell growth and simple cell division. Many species have complex life cycles, however, where cells at various times display activities in addition to or instead of cell growth and simple division. These alternative growth phenomena might be called secondary biological pathways, since no one of them occurs universally among organisms. At least three secondary biological pathways are of widespread occurrence among the lower algae:

(*a*) the division of a cell into a number of daughters at one time, i.e., into zoospores or autospores or gametes;

(*b*) the metamorphosis of a growing cell into a resistant spore; and

(*c*) the appearance in a cell of competence to mate.

These phenomena are not mutually exclusive by

any means—multiple division (*a*) and competence (*c*) occur in sequence in the sexual reproduction of the common sea lettuce, *Ulva*, for example, and sporulation (*b*) follows appearance of competence (*c*) in the mating of the motile green unicell, *Chlamydomonas*. These three pathways do differ from the repetitious pattern of growth and division, and in the examples to be discussed they exist *in addition to* the primary pathways of growth and division. In terms of the observer, they are noteworthy because of their rarity and their striking appearance. For these reasons, many observations of zoospore production, sporulation, and mating have been recorded, and a number of algae have been subjected to intensive investigation of the cause of change in growth pattern. Yet essentially nothing is known of pathways of intermediary metabolism directly involved in zoospore, resting spore, or gamete production.

At our present stage of knowledge, it would be rash to suggest that these secondary biological pathways each represent unique metabolic pathways. They could equally well result from differential shifts in activity of the usual metabolic pathways in a cell. Whatever may be the case, advances in the experimental control of algal life cycles in the laboratory offer the opportunity to study various secondary pathways as entities manipulated by the investigator and perhaps to discover their relationship to the fundamental cell metabolism. The scope of this review, however, will be limited to a presentation of what is known at present about these secondary pathways and to a discussion of some possible approaches to the problem which have not yet been tried with algae.

All three of the phenomena mentioned above are, in a sense, devices for increased survival of the species. They also incorporate for the cells involved an element of danger beyond that to which they are exposed in the usual growth and division; for example, in the formation of multiple daughter cells, each one can receive only a small fraction of the original cell reserves. A cell forming a heavy-walled spore gives up a potential for rapid multiplication in exchange for survival in suspended animation, but is subject to the uncertainties of future germination. And cells forming gametes run the risk of never finding a mate.

For the survival of the species, then, it would be advantageous to incorporate a control system into the genome such that secondary pathways are only utilized at the most propitious time. In the case of multiple division (*a*) this would be when conditions for vegetative growth are most favorable, increasing the chances of survival of daughter cells. For sporulation (*b*), quite the opposite should be the case; a cell should choose this pathway only when facing the alternative of death. Finally, when the population is very low it would be reckless to allow mating competence (*c*) to develop in the cells, and far better to wait until the potential number of partners has increased.

Presumptive evidence for such a control system can be found in the restricted periodicity of sporulation and mating as so frequently observed in nature. The causes of the periodicity can be isolated and studied only in the laboratory, where nature can be copied with considerable success. With zoospore formation, the usual trick is merely to transfer old material to fresh medium, and within the first few days abundant zoospores are produced. As the culture ages, zoospore production ceases, not to reappear until the next transfer. There are several obvious major changes which occur in the environment upon transfer and which might be suspected to serve as trigger mechanisms: provision of renewed nutrients, dilution of old metabolic products, and lowered concentration of organisms with concomitant reduction in secretion products, accumulation of carbon dioxide in the dark, and shading. Moner (1954), studying *Pediastrum*, and Lersten and Voth (1960) using *Enteromorpha* have alike found that medium from old cultures spun free of cells still contains sufficient nutrients to support some zoospore formation, at least for the lowered population of the inoculum. These authors suggest that older cultures contain some self-produced inhibitor to the formation of zoospores. This conclusion is based on the fact that autoclaving "spent culture" medium increases the amount of zoospore production which it is capable of supporting, presumably by destroying the inhibitor. Hustede (1957) draws a similar conclusion for *Stigeoclonium* zoospore production, with the additional suggestion that production of the zoospore inhibitor is enhanced by high light intensities. But here, unfortunately, the problem must be

left, for there is no more experimental evidence on the nature or mechanism of action of any inhibitory substance.

A somewhat more satisfying body of evidence is available on the initiation of the mating reaction. Among various algae the specific stepwise interactions between mating types or sexes leading to the production of a zygote are recognized as complex and are not yet explained on a chemical basis. Discussion of those mating type interreactions requiring the presence of both mating types is omitted here in order to concentrate on the events preceding any specific mating response, for mating competence itself, that is, the metabolic state where a cell can respond to the presence of another mating type, appears only periodically in a culture.

While zoospores are found usually after transfer to a fresh medium, the appearance of mating competence is most often correlated with the end of the log phase of growth. Hustede (1957) reports that with *Vaucheria*, the zoospore production period is some weeks past before male and female gametangia begin to develop in a culture. With algae lacking obvious sexual differentiation, mating competence can be tested by watching for the production of zygotes in selfing strains, or in mixed cultures of compatible strains, or by testing a culture periodically with another compatible but separately maintained culture. Tsubo (1956) has used the mixed culture method with a *Chlamydomonas* species, and Wilbois-Coleman (1958) has tried the separate culture method with *Pandorina*. In both cases the growth rate has begun to decline when mating ability appears at a maximum.

For a constant supply of uniform experimental material in order to study the mating process with these algae, many investigators have preferred to grow cultures on agar or in liquid for a fairly constant period of time, and then to resuspend the cells and subject them to various treatments to induce the competence to mate. It is difficult to generalize about the methods reported because each worker uses his own particular conditions and treatment, as well as his own algal strain, in many cases. Yet investigations by Trainor (1959), and by Bernstein and Jahn (1955), using several *Chlamydomonas* strains and uniform conditions, establish some basis for comparison. Where healthy growing cells are initially harvested, they must be subjected to semi-starvation conditions before they become capable of forming gametes, a principle enunciated more than 60 years ago by Klebs (1896). Sager and Granick's (1953, 1954) investigation of this relationship, more recently, has shown that the nutrient which must be depleted is the available nitrogen. That this is so is shown by the precocious appearance of gametes in media low in nitrogen source, and by the relatively rapid loss of mating ability which occurs when active gametes are provided a nitrogen source. The nitrogen source was the only component of the growth medium which, when provided to gametes, caused this "dedifferentiation." Sager and Granick carried this work to the point of analyzing batches of gametes, originally grown on different media, for their nitrogen content in order to see if a low nitrogen level constantly characterized a gamete. The answer was no; various batches of gametes had nitrogen content, carbon content, and nitrogen to carbon ratios which varied widely and tended merely to reflect their initial conditions of growth. The nitrogen fraction of importance could not be detected by this method.

The nitrogen depletion technique has proven very useful with a number of organisms, yet one does not always come up with an active population of gametes, and furthermore, there are some strains of algae whose gametes seem uninfluenced by the level of nitrogen source in their surroundings, e.g., *Chlamydomonas moewusii* (Lewin, 1956b). Clearly, it would be a considerable advance to know what fraction of the nitrogen metabolism is involved.

Sager and Granick's work has also provided a possible explanation for the frequently reported observation that light is necessary for the production of cells competent to mate. They found that extreme nitrogen depletion in the presence of a carbon source allowed dark-grown *Chlamydomonas reinhardi* cells to undergo all stages of zygote formation in the absence of light. They suggested that the light enhancement of mating found under the more usual conditions of light-grown cells, temporarily placed in the dark, stems from the role of light in photosynthesis promoting anabolic processes in the cell which tie up any remaining free nitrogen. This view is supported by Lewin's (1956b) observations that the light requirement for gamete production has an action spectrum

closely corresponding to that of photosynthesis, and that it is inhibited by a photosynthesis inhibitor, phenylurethan. Yet, at least for the first half hour after light is provided to a culture, CO_2-free air allows the production of just as many gametes as untreated air. Stifter (1959), using another *Chlamydomonas* species, has reported a similar observation which suggests that perhaps any action of light is more concerned with energy absorption than with carbon dioxide fixation and carbohydrate formation.

Increase in temperature of incubation, up to a certain point, has also been used to increase gametic competence with species of *Chlamydomonas* examined by Lewin (1956b), by Förster (1957), and by Trainor (1960). Förster found that such treatment eliminates the requirement of some cells for light. A universal explanation of this phenomenon seems to be lacking; yet some effects of temperature change, known from other fields, may be applicable here. Padilla and James (1960) have reported that transfer of *Astasia longa* cells grown at 15°C to conditions of 25°C heightens their respiration rate over that of cells grown continuously at 25°C. Algal cells may be very sensitive to the changes in carbon dioxide concentration which might result from a sudden stimulation of respiration. One might perhaps go so far as to mention here the remarkable work of Lovett and Cantino (1961) on the water mold *Blastocladiella* where the level of CO_2 concentration determines which road a cell will follow, to form either a resistant sporangium or a zoosporangium. A number of profound metabolic effects of bicarbonate on plant cells have now been established (Squires, Stumpf, and Schmid, 1958), some of which might bear examining here.

All of the factors mentioned so far, nitrogen depletion, light, and temperature, are under continuous study by several investigators, since they obviously play a role in the development of mating competence in a cell. Yet there are a number of changes which occur in a growing culture with the passage of time which have not been examined closely, and which might greatly expand our understanding of mating competence.

First of all, a growing culture removes not only the major nutrient salts from the medium at a nearly exponential rate, but also the trace elements. With the advent of chelating agents and the extensive studies of Hutner, Provasoli, Schatz, and Haskins (1950), of Droop (1959), and of others on the importance and proper use of trace elements, it may be rewarding to examine the role of certain trace elements in mating or in zoospore production. A heightened requirement for a particular element could be a clue to the metabolic pathways especially involved.

Similarly, the growing culture excretes or leaks organic materials into the medium at a rapid rate. Perhaps the most striking example available is the excretion of more than 25 per cent of photosynthetic products by various chlamydomonads growing under high light intensities, as studied by Allen (1956) and by Lewin (1956a). These carbohydrates include polysaccharides and organic acids in some variety. Fogg and Westlake (1955) have reported on nitrogen compounds excreted by algae. There may well be specific growth-controlling substances among these which might accumulate during the growth of a culture, to a point where they could satisfy a threshold requirement for spore or gamete production. Vitamins might be prime suspects in view of the many algae now known to require them (Provasoli and Pintner, 1960). Algae which can grow in the absence of exogenous vitamins, but which show enhanced growth upon vitamin supplementation might be the most suitable material with which to investigate this problem, for, as Trainor (1958) has noted with his vitamin B_{12}-requiring *Chlamydomonas*, an absolute requirement for growth eliminates the opportunity to study the vitamin effect on other pathways. Support for this approach may be found in a recent paper by Morimura (1959) using synchronous cultures of *Chlorella*. Here, only a single cycle of cell division is considered, but vitamin content, expressed as units per cell dry weight, varies considerably. Some vitamins remain constant in amount, some decrease and then later increase, and some increase in amount only before nuclear division. If vitamin concentration is built up over a period of time in an aging culture, it might well influence the basic cell division cycle. At least one case of a vitamin requirement for sexual reproduction has been reported, for the fungus *Zygosaccharomyces* apparently requires vitamin B_6, that is, ribo-

flavin, according to Nickerson and Thimann (1943).

In addition to vitamins, there may accumulate in the aging culture hormone-like growth substances, some of them akin to the hormones of higher plants. The whole phenomenon of an aging culture suddenly expressing a new potential is analogous to some of the recent tissue culture work on higher plants where a tissue such as tobacco pith callus, cultured over a long period, may suddenly initiate shoot or root primordia, the choice being determined by the relative concentrations of auxin and kinetin in the medium (Skoog and Miller, 1956). Relatively little work has been done on the effects of plant hormones on algae, despite the fact that Bentley (1958) has reported auxin-like activity from extracts of pure cultures of *Chlorella* and *Anabaena*, and just recently Radley (1961) has isolated gibberellin-like compounds from *Fucus*. The papers of Provasoli (1958), using *Ulva*, of Conrad, Saltman, and Eppley (1959), using *Ulothrix*, and of Thimann and Beth (1959), using *Acetabularia*, all confirm by careful work and striking results the fact that auxin, gibberellin, and kinetin enhance the growth of algae. Even more applicable here is the work of Hustede (1957), who used *Stigeoclonium* for the study of zoospore production, and *Vaucheria* both for zoospores and for gametangial development. As mentioned previously, zoospores are produced in these algae shortly after transfer to a new medium. Hustede found that suitable concentrations of indole acetic acid, i.e., auxin, or its derivatives could stimulate a ten-fold greater zoospore production than that of controls in a two-day period. A related compound, indole carbonic acid, did not stimulate zoospore production but inhibited it significantly at molarities optimal for auxin; thus it simulated the action of an anti-auxin.

When these compounds were tested on male and female gametangium formation, while using moderately old cultures left in old medium, the anti-auxin stimulated gametangium development in great excess over the untreated controls, which still produced a few zoospores. Auxin added to material containing developing gametangia caused nearly 50 per cent of male gametangia to branch and continue apparent vegetative growth. Thus auxin inhibits sexual reproduction, and enhances asexual growth; anti-auxin reverses the roles. Findings such as these should encourage further hormone investigations of the secondary pathways of algal growth.

Another field now under intensive study with higher plants but largely neglected with algae is that involving phytochrome and the red–far-red light control of many aspects of plant growth and differentiation, particularly photoperiodism. Responses of algae linked to day-night cycles are widespread, from the tide-linked mating of *Ulva* to the phenomenon common to many algae of carrying on nuclear division during the night, followed by zoospore or gamete release shortly after dawn. Daily periodicities in the respiration of *Hydrodictyon*, evoked by the previous light-dark regime, continue for several days after the algae are placed in continuous darkness (Pirson, 1957). With this phenomenon in mind, it seems particularly interesting that at least one system in algae can be controlled experimentally by red–far-red light. Haupt (1959) has studied the orientation of the plate-like chromatophore of *Mougeotia* cells toward the light. The action spectrum for this orientation shows a single major peak at approximately 680 $m\mu$, very close to the 660 $m\mu$ peak characteristic of higher plants; and, what is more conclusive, the effect of red light at 680 $m\mu$ can be eliminated by a subsequent treatment with far-red light of approximately 720 $m\mu$, a wave length which again is very close to the far-red peak effective in higher plants. The reversal treatment, to be completely effective, must follow within one minute of the original red light stimulus.

The many studies of algal growth using synchronized cell cultures have, so far, ignored the problems of physiological changes other than those in the basic cycle of growth and division. The simple explanation for this is that studies have generally used *Chlorella*, *Scenedesmus*, or *Euglena*, none of which have sexual stages, or other alternatives to growth and division. Furthermore, most synchronous cell studies end after one or two rounds of division, so that cultures are never allowed to age. These studies have, however, revealed a wealth of knowledge about metabolites which do change in cell growth, and pinpoint some which may be expected to play a further role. Some examples

are: the interrelation of nitrogen source and phosphate storage (Hattori, 1960; Schimdt, 1961), the time course of deoxyribonucleic acid synthesis (Iwamura and Meyers, 1959), the special role of a sulfur-containing deoxypentose polynucleotide compound in cell division (Hase, Mihara, and Tamiya, 1961), and the variation in vitamin synthesis during the cell cycle (Morimura, 1959). Now that Cook and James (1960) have shown that it is possible to keep cultures permanently synchronized by suitable use of alternate dark and light periods, and have succeeded in doing this with *Euglena* in a chemically defined medium, it should at last be possible to answer such simple and ancient questions as "when is a cell too old to act as a gamete?"—perhaps it is when its DNA has doubled. Now it is time to establish the biochemical basis of changes in the life cycle of algae.

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COMPLEMENTARY GENETIC CONTROL OF DIFFERENTIAL COMPATIBILITY IN RUSTS

Theoretical Application to Analysis of Host-Obligate Parasite Interaction

B. ARTHUR L. FLANGAS AND JAMES G. DICKSON

Department of Plant Pathology, University of Wisconsin, Madison

ABSTRACT

A genetic analysis of pathogenic and antigenic specificity of Puccinia sorghi *on four dominant alleles at the* Rp *locus and on two recessive alleles for resistance in lines of corn permits a theoretical interpretation of genetic control of host-obligate parasite interaction in the light of recent biochemical genetical concepts. The dominant alleles at the* Rp *locus condition resistance (incompatibility manifested as necrotic fleck) and score a varying spectrum of pathogenic types in the fungus. Each allele is differentially vulnerable (compatible to infection in varying degrees) to one or more pathogenic types of the fungus. The four alleles are complementary in varying dimension, i.e., both qualitatively and quantitatively, in conditioning rust reaction. The alleles apparently do not influence antigen production in the pathogen significantly. The gene structural analysis of the* Rp *locus is presently impractical because of the paucity of mutant markers in this region of chromosome X.*

The data on inheritance of pathogenecity and serotypes in the dicaryon of P. sorghi *indicate a complex genic mechanism not resoluble by the application of simple Mendelian concepts alone. The four urediospore clones used were heterozygous for pathogenecity and serotypes. Analysis indicated an indeterminate inheritance with a continuous potential for variation. The genetic unit of complementary function and specificity in a dicaryon line was not constant on the host alleles but became reduced or expanded in complementarity by genetic recombination. The present data do not indicate the fraction of the total genotype that is utilized in conditioning complementarity of fit to a specific differential allele in the host. The use of the genetic linkage map of the pathogenic genotype is impractical in these dicaryotic, obligate parasites; therefore, immunochemical and biochemical methods must be developed to explore the magnitude, structure, and function of the pathogenic locus in* P. sorghi *and the* Rp *locus in the host.*

At this stage of investigation a framework of ideas intended to relate the data on rust reaction to chromosome organization and gene function must be theoretical. The critical review of recent investigations on the biochemical genetics of microorganisms may indicate where to probe for additional evidence on the nature of the reactions and their genetic regulation.

INTRODUCTION

KNOWLEDGE of the precise structural geometry of molecules involved in biological reactions is opening new possibilities for understanding biochemical processes and their control. Structural analysis of biological molecules such as nucleic acid and hemoglobin, with the aid of genetic, serological, and new physicochemical analyses is correlating structure with function of these molecules (Ingram, 1957; Pontecorvo, 1958b; Ris, 1957). The success of the Cambridge group (Watson and Crick, 1953; Crick, 1957, 1958) and others in the establishment of the structure of deoxyribonucleic acid (DNA) and its relation to ribonucleic acid (RNA) as the templates in the right milieu on which new protein is manufactured, suggests the biochemical mechanism for elucidating the processes of heredity. The genes of the chromosome emerge as epiphenomena; they are not basic structural singularities but they result

from interactions between parts of the basic chromosome structure (Benzer, 1957; Pontecorvo, 1958b; Ris, 1957).

These studies and those on the current concept of enzyme induction (Jacob and Monod, 1959; Szilard, 1960) suggest that the function of biological molecules, dependent upon their configuration, is unified in analysis with the genetic mechanism determining the origin of specificity. The genetic mechanism is dependent on its own structural configuration for specific function and duplication. The importance of this integrated interaction that links the genetic origin of geometrical variation ultimately to that of biological molecules and their functions emphasizes the complementarity of fit needed for harmonious action between all such molecules in a living system. They must fit each other in such a way that the right parts are brought into conjunction to interact chemically.

Application of this precise system of interaction need not be confined to integrated reactions within a single, living cellular unit. The harmonious interactions of two genic systems entering into a compatible relationship is a logical extension of this biological phenomenon. The precision involved is shown in the interaction of an independent genic system with a dependent or partial system in the relationships of specificity known to condition reaction between host-virus or phage systems (Benzer, 1957; Thung, 1931). The precision necessary for interaction between a host-virus system for a lower organism is demonstrated in the genetic control of plaque formation or reaction specificity by the *rII* region of the T4 bacteriophage on strains of *Escherichia coli* (Benzer, 1957). The genetic configuration of a single functional unit, or "cistron," in the bacterial host determines the compatibility or incompatibility of the interaction, i.e., the complementarity of fit of the infectious virus and the ultimate reaction type.

A similar order of precision is suggested in higher plants in their acquired immunity to related viruses. This reaction, in which related viruses introduced into higher plants are mutually antagonistic and interfere with each other, is widely known as "cross-protection" (McKinney, 1929, 1941; Price, 1935; Thung, 1931). It appears to be based on the mutual or reciprocal exclusion of similar viruses (molecular structures) from specific sites of function in the host. A structural relationship in the virus pairs that show mutual antagonism in the host is further shown from their positive serological reactions, and vice versa (Mathews, 1949).

The ultimate extension of this precise molecular system to the interaction of two independent genic systems, as in that of host–obligate-parasite relations in the rusts, needs consideration. Numerous examples of obligate parasitism between independent genic systems are known both in animals and plants. The specificity of obligate parasites in animals seems to be of parallel magnitude to that recognized in plants. Although numerous attempts have been made to cultivate these obligate parasites artificially, for example, malarial parasites of animals and rust pathogens of plants (Trager, 1957; Cutter, 1959), progress in determining the specific phenomena involved has been slow. The best nutritional analysis of the specificity of avian malarial parasites, by Trager and various colleagues (1957), predicts an enzyme basis of specificity. A similar magnitude of specificity is predicted by investigators of plant obligate-parasites such as rusts and powdery mildews (Allen, 1954; Daly and Sayre, 1957; and others). The present theoretical treatment of specificity is based on genetic, serological, cytological, and nutritional analysis of host and obligate-parasite relations (Flangas and Dickson, 1961; Flor, 1959; Pavgi, Cooper, and Dickson, 1961; Samborski, Forsyth, and Person, 1958).

The discussion which follows reviews the genetic precision involved in rust pathogenesis. The data suggest the logical extension of the theoretical concept of interaction and complementarity of fit of harmonious reactions within a living cell to include the interaction of independent genic systems within the closely associated living cells in the host and obligate-parasite interactions. The complementary relationships applied to the data on genetic analysis of host-parasite reactions in maize rust are derived from the genetic model used in defining the molecular control of enzyme induction and antibody formation (Jacob and Monod, 1959; Monod, 1959; Szilard, 1960).

The induced synthesis of protein in bacteria is currently thought to be controlled by two kinds of genetic factors: (1) the structural gene,

which contains the genetic information determining the structure of this particular protein; and (2) a regulator, or operator, gene which determines the production of a specific repressor acting as a cytoplasmic message controlling the expression of the structural gene (Jacob, Schaeffer, and Wollman, 1960). From the two cases in bacteria reported by these authors, it appears that the structural gene, as a rule, controls the synthesis of a single protein and that the regulator, or operator, gene represses the synthesis of several enzymes, which although different belong to the same metabolic sequence (Jacob and Monod, 1959).

Genotypes involved in the maize-rust reaction (Lee, 1961; Flangas and Dickson, 1961; Russell and Hooker, 1959) are found to describe the similar complementary catalytic reactions defined for enzyme induction (Pollock and Mandelstam, 1958), and provide the methods for elucidating the nature of specificity, the origin and isolation of the biological molecules involved, and perhaps ultimately an analysis of the precise geometry of the molecules conditioning the biochemical reaction of differential compatibility in the maize host and the obligate-parasite relations.

Complementarity of fit and its application to the genetic interactions of the maize host and rust pathogen are treated more fully later in the paper. The analysis of the genetic units involved in the interacting genotypes and their structural configuration are at present based on the phenotypic expression of the rust reactions. Biologically these include not only the specific units (genes on similar units controlling formation and duplication) in the diploid host and dicaryon parasite, but also the effect of other units associated with these and the structural configuration at the loci involved in each genotype on the expression of rust reaction.

The interacting genotypes function in a complementary manner in conditioning rust reaction. The term complementarity of fit is used to express the dynamics of the interacting genotypes on the phenotypic expression of the uredial reactions. The type or degree of complementarity of fit between the interacting genotypes is defined on a geometric basis in Table 4.

The rust reaction is compatible when the functional units of the complementary genotypes are in the homologous state, that is, when the functional units are in the same or a like relative relationship. The reaction is incompatible and necrotic flecks result when the functional units are in the non-homologous state. And finally, the intermediate uredial reactions, including the mesothetic **X**, are manifest when the units are in the heterologous state either due to unit deletion or to the heterozygous condition of the genotype of host or parasite or both. Detailed theoretical illustrations are given in the discussion of Table 4.

The phenotypic expression of rust reactions correlated with the theoretical expression of the dynamics of the interacting genotypes in a complementary manner reveals discrete reactions that are manifest experimentally. Two kinds of susceptibility are revealed, active and passive. Active susceptibility, as in maize lines GG208R, Cuzco, B38 and K148, is both adaptive and complementary, and therefore, differential in phenotypic expression. The present susceptible uredial reactions recorded range from **2** in Cuzco to **3** and **4** in the other alleles. Passive susceptibility, as in maize lines P39 and B14, is both non-adaptive and non-complementary, and therefore, shows only the susceptible **3** to **4** uredial reaction to all lines of the rust fungus tested. The phenotypic expression of specificity in active susceptibility becomes the degree of complementarity of fit manifest between genetic configurations, and it is identified by the spectrum of uredial reaction types recognized in rust pathogenesis.

Experimentally, the increase in precision of the complementarity of fit in the interacting genotypes is expressed in relation to the compatibility gradient or phenotypic manifestation of necrotic fleck and uredial reaction types. Both the genotypes interacting and the environment are involved in the ultimate expression of uredial types in a precise gradient form. The intermediate uredial types of the compatibility gradient usually are the more elusive because they tend to integrate and apparently are more sensitive to biochemical changes in the interacting cellular media of host and pathogen.

IDEAL HOST-PARASITE RELATIONS

The specific determination of the rust reaction of the host-pathogen interaction is demonstrable on a genetic basis. Resistance or susceptibility to a particular uredial clone of the pathogen often depends upon a single gene pair in the host (Flor, 1956, 1959; Russell and

Hooker, 1959; Lee, 1961). Pathogenicity and nonpathogenicity in the pathogen also is on a genetic basis, so that susceptibility of a potential host plant is dependent partly on the genotype of the pathogen. Flor (1956) first described this host-parasite relationship in flax rust (*Melampsora lini*) as the interaction of complementary genic systems, i.e., as the result of specific genes in the host interacting with specific genes in the parasite. Accordingly, on flax varieties possessing one gene for resistance to the avirulent parent race, pathogenicity is conditioned by one gene; on flax varieties possessing two, three, or four genes for resistance to the avirulent race, respectively, pathogenicity is conditioned by two, three, and four genes, respectively, in the fungus. The simplest hypothesis that fits these facts is that for each gene conditioning reaction in the host there is a complementary or reciprocal gene conditioning pathogenicity in the parasite. This hypothesis was corroborated by Person (1959), who demonstrated that Flor's flax rust reaction data fit an ideal genetic model of host-parasite relations.

The complementary relationship of genes for this simplest fit of rust reaction in the host with those for pathogenicity in the parasite is shown in Table 1. The symbols *R* (resistance, dominant) and *r* (susceptibility, recessive) are used to indicate differential susceptibility in the host, and *A* (avirulence, dominant) and *a* (virulence, recessive) to indicate pathogenicity in the rust. The host reaction to the different combinations of one set of host-parasite complementary genes is summarized in Table 1. Two phenotypic rust reaction types, **0;** (resistant) and **3-4** (susceptible) are postulated by this model. On the basis of this model of host-parasite relations, the incompatible reaction (**0;**) occurs only when complementary genes in both the host and parasite are dominant, and the compatible reaction (**3-4**) when both are recessive. A few instances of recessive genes conditioning resistance in both flax and corn are known, but have been inadequately studied.

Implicit to this gene-for-gene reaction is a 1:1 homology of the structural configuration of the competent loci of the two complementary genic systems interacting (Flangas and Dickson, 1961). This ratio is realized (Table 1) because of recognition of only two phenotypic reaction classes (resistant and susceptible) and establishment of an ideal genetic model of host-parasite relations (Flor, 1956, 1959; Person, 1959). The uredial reaction types of rust pathogens occurring naturally and first described qualitatively by standardized symbols (Stakman, 1915) are as follows: no visible reaction, **0** and necrotic fleck, **0;** being the resistant reactions; **1**, minute uredia surrounded by a necrotic area; **2**, small uredia surrounded by a chlorotic area; **3**, medium-sized uredia frequently associated with chlorosis; **4**,

TABLE 1

Ideal genetic model of host-parasite relations, the simplest to fit the rust reaction types recognized: type **0;**, *resistant; types* **3-4** *susceptible*

Differential Host Genotype (Alternative configuration)	Pathogen Genotype (Alternative configuration) AA	Aa	aa
RR	0;	0;	3–4
Rr	0;	0;	3–4
rr	3–4	3–4	3–4

Host Genotype
RR – Resistance Dominant
rr – Susceptibility Recessive

Pathogen Genotype
AA – Avirulent Dominant
aa – Virulent Recessive

large confluent uredia with little chlorosis; and mesothetic **X**, or indeterminate type of infection, in which large and small uredia occur surrounded by various degrees of necrosis and chlorosis (see Fig. 3). The **0** type reaction in which the fungus infection-hyphae enter the substomatal cavities without further elongation or effect on adjacent host cells apparently does not occur in maize rust.

The resolving power of progressive inbreeding and genetic recombination shown in the analysis of the pathogenicity and serotypes of *Puccinia sorghi* Schw. demonstrates that by grouping the several reaction types into two phenotypic classes for an ideal host-parasite system we preclude the explicit analysis of the pathogenic locus in the fungus, its genetic configuration, and its functional specificity or reaction type (see Tables 2 and 4). Some of the inbred recombinant lines of the pathogen incite the **2** and the "mesothetic **X**" reaction types on the differential hosts as well as the susceptible reaction on lines B14 and P39. Also on the basis of the resistant and susceptible reactions only, single genes in the host conditioning rust reaction are demonstrable, but they do not evaluate complementarity between the alleles at the *Rp* locus in maize nor reveal the significance of the **X** reaction that occurs in the heterozygotes between the alleles (see Table 4 and Fig. 3, E and F).

The precision and validity of the interpretation on a genetic basis of a host-obligate parasite interaction is thus shown to depend upon the experimental model used to extract genotypic information from phenotypic response. The sensitivity of both the pathogenic and antigenic locus, or loci, in *P. sorghi* to modification through inbreeding and genetic recombination (Flangas and Dickson, 1961) demonstrates a complex inheritance involved in conditioning variability in the fungus. Inbreeding through four generations of sibling matings through the aecial host (Fig. 1) did not reduce the number of pathogenic types and serotypes recovered from successive recombinant uredial or dicaryotic generations nor indicate that the lines progressed in homozygosity for these factors. The full range of phenotypic reaction types recovered in rust pathogenesis of the inbred lines and their hybrids (Table 2) appeared to warrant recognizing them as specific responses of differential compatibility instead of grouping them into two phenotypic classes as done in the ideal genetic model given in Table 1.

The use of the full range of phenotypic reaction types demonstrated the unitary control of complementarity of fit described in gene-for-gene control of parasite reaction-specificity. Its use demonstrated also that the functional 1:1 complementarity of fit in the specific host-parasite interaction does not define homology of locus dimension in the host or the pathogen. The complex genic system demonstrated in urediospore clones of *P. sorghi* conditioning pathogenic specificity revealed that the unit of complementary function was not constant but became reduced or expanded in reaction specificity toward the host alleles by means of genetic recombination (see Table 4). The relative genetic magnitude (number and configuration of the nucleotide pairs) conditioning unitary rust reaction-type in *P. sorghi* was found to be based on the configurational state (active or passive configuration) of the indeterminate functional unit conditioning complementarity of fit in the host-parasite interaction (Flangas and Dickson, 1961).

COMPLEMENTARY ACTIVITY MODEL OF HOST-PARASITE RELATIONS

Functional analysis of host-parasite relations determined by the relative complementary action of the different genetic configurations obtainable expands the concept of the ideal genetic model illustrated in Table 1 so as to account for the full range of rust reaction types expressed naturally.

Host genotype control of the full range of reaction types to different combinations of 5 host-parasite complementary configurations is shown in Table 3. The original culture 3-32 and derived sibling subcultures 3-32-03, 3-32-03-13, -30, and -39 were made to interact on homozygous and heterozygous states of the two dominant alleles in Golden Glow and Cuzco Maize and a passive susceptible allele of line B14 (*RR*, *R′R′*, and *rr* respectively). The full range of phenotypic reaction expressed and their distribution in the F_2 and back-cross populations demonstrated the unitary control of reaction specificity at the *Rp* locus in maize, as well as revealing an intrinsic mechanism for conditioning variation in phenotypic expres-

TABLE 2

Pathogenic reactions of 4 original urediospore clones (1-20, 2-22, 3-32, and 4-1) on 6 differential maize lines and passive susceptible line B14; and of 285 subcultures and 92 hybrids derived from successive inbreeding and hybridization of the aecial inbred recombinants recovered from the 4 original urediospore cultures

Original cultures differentiated on 4 dominant alleles for resistance Cuzco 1b, GG208R, B38, and K148 homozygous at the *Rp* locus in maize and 2 pairs of recessive genes for resistance, both of them nonallelic to the *Rp* locus, in each of the susceptible lines Pop 35 and Pop 36. See references (Flangas and Dickson, 1961; Lee, 1961; Russell and Hooker, 1959) for detailed inheritance studies.

Reactions indicated are **0**; (resistant hypersensitive reaction); **1** (resistant); type **2** (moderately susceptible reaction); type **3-4** (susceptible reaction); and type **X** (mesothetic reaction). See references (Stakman, 1915; Stakman and Levine, 1922) for original description of reaction types and use to identify biologic forms of *Puccinia graminis tritici* (Pers.) Erikss., and Henn.

Pathogenic reaction of original urediospore cutures

Original culture	Cuzco 1b	B38	GG208R	K148	Pop 35	Pop 36	B14
1–20	0;–1	0;–1	0;–1	0;–1	3–4	3–4	3–4
2–22	0;–1	0;–1	0;–1	0;–1	3–4	3–4	3–4
3–32	0;–1	0;–1	3–4	0;–1	3–4	3–4	3–4
4–1	0;–1	0;–1	0;–1	0;–1	3–4	3–4	3–4

Reaction of subcultures and hybrids obtained from aecial inbred recombinants

Pathogenic types	Subculture variation	Differential corn line							Pathogenic types: Frequency of occurrence
		Cuzco 1b	B38	GG208R	K148	Pop 35	Pop 36	B14	
Type a	a	0;–1	0;–1	0;–1	3–4	3–4	3–4	3–4	26
	a_1	0;–1	0;–1	0;–1	3–4	3–4	X	3–4	13
	a_2	0;–1	0;–1	0;–1	X	3–4	3–4	3–4	12
	a_3	0;–1	0;–1	0;–1	X	3–4	X	3–4	17
Total a									68
Type b	b	0;–1	0;–1	0;–1	0;–1	3–4	3–4	3–4	65
	b_1	0;–1	0;–1	0;–1	0;–1	3–4	X	3–4	77
	b_2	0;–1	0;–1	0;–1	0;–1	X	X	3–4	19
Total b									161
Type c	c	0;–1	0;–1	2	0;–1	3–4	3–4	3–4	32
	c_1	0;–1	0;–1	X	0;–1	3–4	3–4	3–4	7
	c_2	0;–1	0;–1	2	0;–1	X	X	3–4	3
	c_3	0;–1	0;–1	2	0;–1	3–4	X	3–4	2
Total c									44
Type d	d	0;–1	0;–1	0;–1	0;–1	0;–1	3–4	3–4	23
	d_1	0;–1	0;–1	0;–1	0;–1	0;–1	X	3–4	5
Total d									28
Type e	e	0;–1	3–4	0;–1	3–4	3–4	0;–1	3–4	4
	e_1	0;–1	X	0;–1	3–4	X	0;–1	3–4	2
Total e									6
Type f	f	0;–1	0;–1	0;–1	3–4	3–4	0;–1	3–4	4
	f_1	0;–1	0;–1	0;–1	X	3–4	0;–1	3–4	1
	f_2	0;–1	0;–1	0;–1	X	X	0;–1	3–4	1
Total f									6

TABLE 2—*Concluded*

Pathogenic types	Subculture variation	Differential corn line							Pathogenic types: Frequency of occurrence
		Cuzco 1b	B38	GG208R	K148	Pop 35	Pop 36	B14	
Type g	g	0;-1	X	0;-1	3-4	3-4	3-4	3-4	16
	g_1	0;-1	X	0;-1	X	3-4	3-4	3-4	7
	g_2	0;-1	X	0;-1	3-4	3-4	X	3-4	8
	g_3	0;-1	X	0;-1	X	3-4	X	3-4	7
	g_4	0;-1	3-4	0;-1	3-4	3-4	X	3-4	6
	g_5	0;-1	3-4	0;-1	X	3-4	3-4	3-4	1
	g_6	0;-1	X	0;-1	X	X	X	3-4	1
Total g									46
Type h	h	0;-1	X	0;-1	0;-1	3-4	0;-1	3-4	1
Total h									1
Type i	i	2	0;	2-X	0;	3-4	3-4	3-4	2
	i_1	2	0;	2	0;	3-4	X	3-4	2
Total i									4
Type j	j	0;-1	0;-1	0;-1	0;-1	0;-1	0;-1	3-4	2
Total j									2
Type k	k	0;-1	3-4	2	3-4	3-4	3-4	3-4	3
	k_1	0;-1	X	2	3 4	3-4	3-4	3-4	3
Total k									6
Type l	l	0;-1	0;-1	2	X	3-4	3-4	3-4	1
	l_1	0;-1	0;-1	2	X	3-4	X	3-4	3
	l_2	0;-1	0;-1	2	X	X	X	3-4	1
Total l									5
Grand Total									377

sion detected by the specific complementary recombinant genotypes reacted (see Fig. 3, D and E). The ideal unitary control of the host reaction to the different combinations of one set of host-parasite complementary configurations, designated on a Mendelian basis and including a mechanism for intrinsic variation, is summarized in Table 4. Compatibility on the differential host genotype ideally is seen to occur only when active configurations, i.e., (+) configurations, interact and produce the type **4** reaction. Experimentally, however, compatible host-parasite relations on both active and passive susceptible host configurations (see Fig. 3, A and G) include uredial pustule types ranging between **3** and **4**. Accordingly, interaction of an active (+) or an intermediate (+ −) host configuration with a passive (−), intermediate (− +), or active (+) parasite configuration (Table 4), results respectively in incompatible, moderately compatible, or completely compatible association and produces uredial types **0**; or **1**, **2** or mesothetic **X**, and **3** or **4**, respectively. On the other hand, interaction of a passive (−) host configuration with an active (+), intermediate (− +), or passive (−) pathogenic configuration results only in the production of the compatible type **3-4** reactions. Apparently, an active differential compatibility mechanism has evolved in the host with the passive configuration.

The phenotypic response and detailed histological analysis of the full range of compatibility (specificity) expressed on the two host genotypes **GG208R** (differential) and **P39** (homozygous passive susceptible) by three lines of the

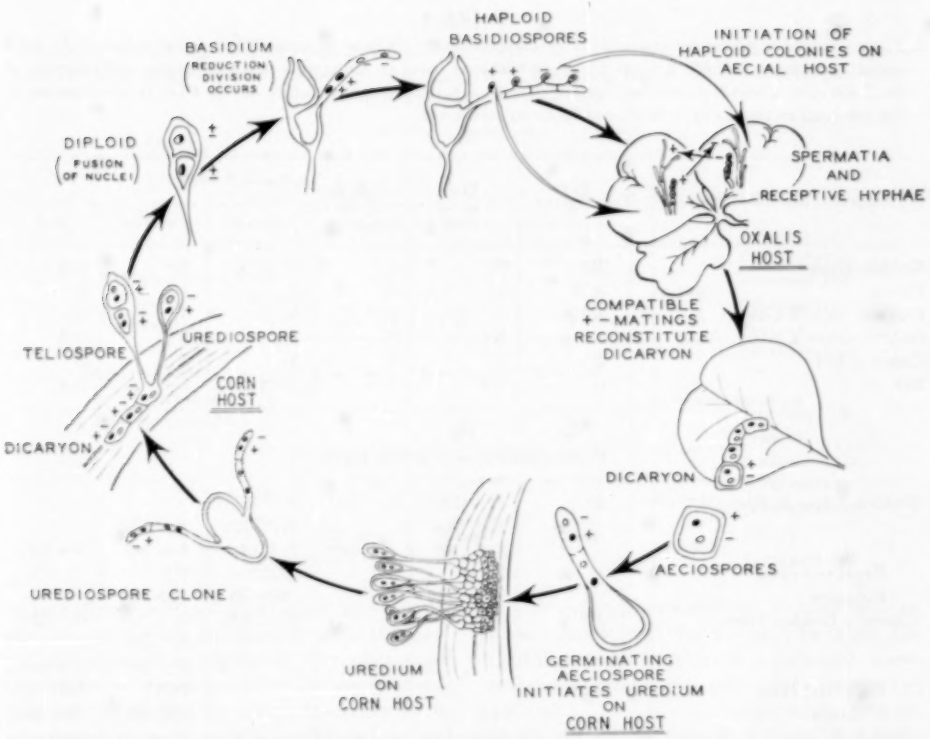


FIG. 1. THE LIFE CYCLE, NUCLEAR BEHAVIOR, AND NUCLEAR COMPATIBILITY (+ −) REACTIONS OF *Puccinia sorghi* AS DEVELOPED IN THE UREDIAL HOST, *Zea mays*, AND IN THE AECIAL HOST, *Oxalis corniculata*

Starting with the single urediospore clone, the dicaryon, diploid, haploid sequence is illustrated and the + − compatibility reactions are shown. Combining + − spermatia and receptive hyphae from the same clone results in inbreeding, and the resulting aeciospores represent the inbred recombinants. Hybrids are produced by combining + − spermatia and receptive hyphae from separate clones.

pathogen, 1-20, 3-32, and c-3-32-03, are shown in Figs. 2 and 3. The histological preparations indicate early necrosis of the guard and mesophyll cells of the host, and death of the hypha of the fungus, at the infection sites of the fungus line 1-20 inciting the necrotic fleck reaction on GG208R (Fig. 2, C and D), in contrast to apparently no cytoplasmic reaction beyond an initial reduction in chlorophyll formation at the infection site when line 3-32 incites the fully compatible reaction on GG208R and P39 (Fig. 2, A and B). In the heterologous specific (mesothetic-**X**) parasitic reaction incited by line c-3-32-03 on GG208R, both necrotic flecks and uredia develop simultaneously with the characteristic host tissue reaction, although the two reaction types are not in close association in the host-leaf tissue (Fig. 3, D). This **X** type of reaction is inherited and breeds true for the specific host-pathogen combination. The three fungus lines, although differentially compatible on GG208R, all incite the full compatible reaction on the homozygous (passive) susceptible lines P39 (Fig. 2, B) and B14 (Fig. 3, G).

Theoretically, as shown in Table 4, two kinds of susceptibility are revealed by the complementary activity model of host–obligate-parasite relations, namely, active and passive susceptibility. Active susceptibility, as in lines GG208R and Cuzco, is both adaptive and complementary (see Table 3). The phenotypic reaction type in active susceptibility is dependent on the degree

TABLE 3

1. *Genetic control of phenotypic expression of rust reaction at the Rp locus in maize. The original culture 3-32 and 4 sibling subcultures 3-32-03, 3-32-03-13, 30, and 39 were tested on homozygous and heterozygous configurations of the 2 dominant alleles Golden Glow and Cuzco and the passive susceptible allele in line B14. II. Distribution of reaction types on the alleles in the F_2 and backcross populations*

I.

Pedigree at Rp locus in maize	Host genotype	Pedigree line of *P. sorghi*				
		3-32-03[b]	3-32-03-39[c]	3-32-03-30[c]	3-32-03-13[c]	3-32[a]
Golden Glow[g]	*RR*	0;	0;	0;	X[e]	3–4
Cuzco	*R'R'*	0;	0;	0;	2	0;
Golden Glow x Cuzco	*RR'*	0;[f]	0;[f]	0;[f]	0;[f]	0;[f]
Golden Glow x B14	*Rr*	X_2[d]	0;	X_2[d]	X_2[d]	3–4
Cuzco x B14	*R'r*	2	0;	1	2–3	2
B14	*rr*	3–4	3–4	3–4	3–4	3–4

II.

F_2 distribution of reaction types

(Golden Glow X B14)	*Rr*	0; (15)[h]	0; (18)	0; (5)		
		X_2[d] (26)		X_2[d] (12)	X_2[d] (20)	
		3–4 (16)	3–4 (6)	3–4 (4)	3–4 (4)	3–4 (26)
Expected ratio		1:2:1	3:1	1:2:1	3:1	
P values		.80–.70	.99	.80–.70	.50–.30	
(Cuzco x Golden Glow)	*RR'*	0; (20)	0; (21)	0; (23)	0; (11)	0; (20)
					X[e] (7)	
					2 (4)	3–4 (6)
Expected ratio					1:2:1	3:1
P values					.70–.50	.90–.80

Backcross distribution of reaction types

(Cuzco x Golden Glow)	*R'R*	0; (25)	0; (29)	0; (26)	0; (13)	0;[f] (13)
x	x				X[e] (10)	
(Golden Glow)	*RR*					3–4 (14)
Expected ratio					1:1	1:1
P values					.70–.50	.90–.80
(Cuzco x Golden Glow)	*R'R*		0; (28)	1 (9)		0; (11)
x	x	X_2[d] (9)		X_2[d] (7)	X_2[d] (16)	
B14	*rr*	3–4 (12)			2 (14)	3–4 (10)
Expected ratio		1:1		1:1	1:1	1:1
P values		.70–.50		.70–.50	.80–.70	.90–.80

[a], [b], [c] Original culture 3-32 with recovered sibling recombinants inciting the full range of phenotypic response (**0;**, **1**, **2**, **3**, **4**, and **X**) on the differential host alleles Golden Glow and Cuzco. The **3–4** reaction type incited on the homozygous passive susceptible line B14 remained constant, whereas F_1 heterozygote configurations vary. The F_1 configurations are reflected again in the F_2 and backcross progenies by the distribution of reactions recovered.

[d] F_1 and F_2 mesothetic X reaction, associated with large necrotic regions and reflecting a similar genotypic origin.

[e] P_1 and F_2 mesothetic X reaction, not associated with large necrotic regions and reflecting a similar genotypic origin.

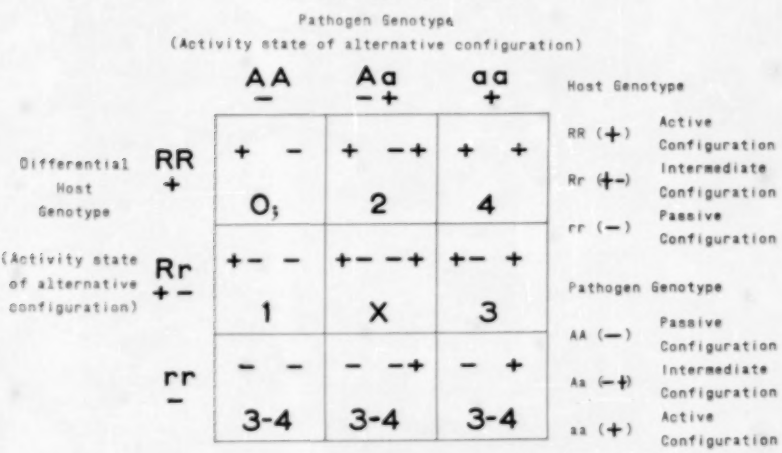
[f] F_1 and F_2 nonspecific **0;** reaction type, reflecting a similar genotypic origin and noncomplementarity of the heterozygous configuration at the Rp locus for susceptibility.

[g] The differential host allele in Golden Glow is identified as being the same as in strain GG208R in reaction, and was derived from similar source material (Lee, 1961).

[h] Number of maize seedlings used in F_2 and backcross distribution of reaction types.

TABLE 4

Complementary activity model of host-parasite relations; the simplest to fit the several rust reaction types recognized: types **0;**, **1** *incompatible, type* **2** *moderately compatible, type* **X** *mesothetic reaction indeterminate compatibility, and types* **3–4** *completely compatible*



of complementarity of fit existing between the two complementary configurations in the host-parasite interaction (Table 4). The phenotypic expression of specificity in active susceptibility becomes the degree of complementarity of fit manifested between genetic configurations and is identified by the several reaction types recognized in rust pathogenesis. Accordingly, the spectrum of reaction types expressing the degree of complementarity of fit defined on a geometric basis is resolved into **0;** and **1** (incompatible), the result of nonhomologous complementarity of fit; **3-4** (compatible), the result of homologous complementarity of fit; and type **2** and mesothetic **X** reactions (moderate or indeterminate compatibility), the **X** reaction being the result of heterologous complementarity of fit in the host-parasite interaction. Passive susceptibility (*rr*), as in maize lines P39 and B14, is both nonadaptive and noncomplementary, and therefore shows only the susceptible host-parasite phenotypic reaction.

The degree of complementarity of fit and resultant reaction types expressed are also correlated with the heterogeneity of activity of the different configurational components associated (Table 4). The nature of the balance between the different configurations associated in the complementary activity model reveals a unique configurational balance possible for each of the six reaction types recognized. Accordingly, reaction types mesothetic **X** and **4** in active susceptibility result only from a balanced associated configuration, viz., only combinations (+) (+) and (+ −) (− +), respectively. On the other hand, uredial types **0;**, **1**, **2**, and **3** of active susceptibility result when unbalanced configurations are associated (Table 4). Furthermore, a compatibility gradient is noted as the associated configurational components progressively approach the balanced type **4** and mesothetic **X** conditions. This gradient runs from the unbalanced type (+) (−) **0;** through unbalanced types (+ −) (−) **1**, (+) (− +) **2**, (+ −) (+) **3**, to the balanced (+ −) (− +) type **X** and finally (+) (+) type **4**. The noncomplementary, passive susceptible system of the complementary activity model does not differentiate between the balanced (−) (−) or unbalanced (−) (− +) and (−) (+) configurations associated for reaction; consequently, differential complementary action of the alternative configurations associated with resultant reaction type does not occur in the passive susceptibility.

Ultimately (see Table 4), homologous reaction type follows an increase of configurational precision or degree of complementarity of fit manifested between the configurational components interacting, as the compatibility gradient approaches the balanced condition. The

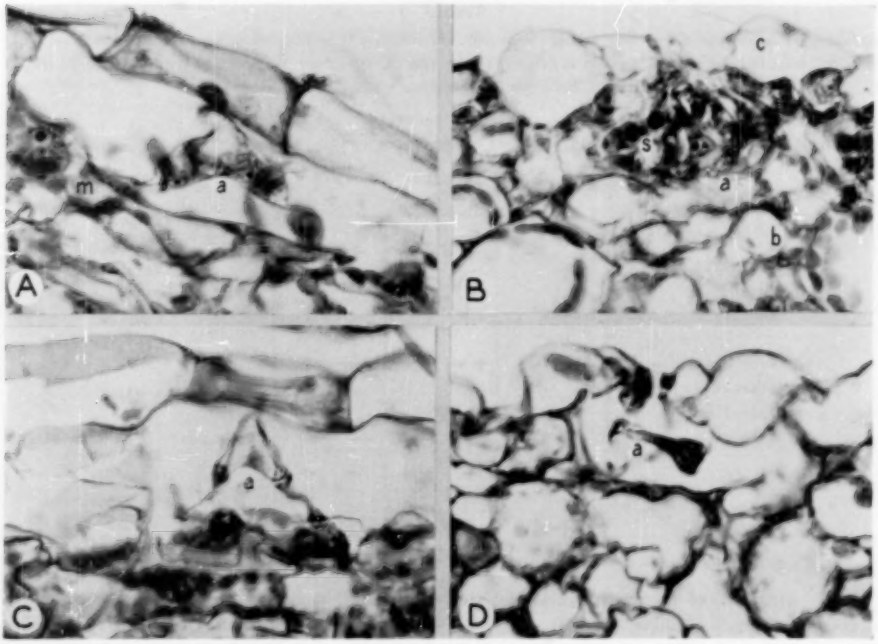


FIG. 2. HISTOLOGICAL DETAILS OF PHENOTYPIC EXPRESSION OF COMPATIBLE (SUSCEPTIBLE) AND INCOMPATIBLE (RESISTANT) INTERACTIONS OF MAIZE AND *Puccinia sorghi* GENOTYPES

To illustrate the two extremes in complementarity of fit in obligate parasite interaction. A, Compatible (active susceptible) reaction of line 3-32 of *P. sorghi* to Golden Glow (GG) allele (*RR*) at *Rp* locus 2 days after inoculation at 24°C. Longitudinal-section of leaf, magnified × 1200. Characteristic bilobed vesicle of *P. sorghi* (a) in substomatal cavity of corn leaf with hyphal branch from apex of each lobe advancing between mesophyll cells (m) of host. The nuclei and cytoplasm of host and parasite are fully functional, although the cells of the mesophyll are slightly out of focus. B, Compatible reaction 6 days after inoculation at 24°C. Cross section of corn leaf, × 1200, showing sporogenous, dicaryon hyphae (s) compacted in the substomatal cavity; hyphae between the mesophyll cells (a); and haustoria (b) in the mesophyll cells. The epidermal cells (c) of the leaf intact over the sorus. C, Incompatible reaction (necrotic fleck) incited by line 1-20 of *P. sorghi* to *RR* allele of Golden Glow maize 2 days after inoculation at 24°C. Longitudinal section of corn leaf, × 1200. Bilobed vesicle (a) in stomatal cavity; hyphae are collapsed, and nuclei and cytoplasm lysed. The adjacent mesophyll cells of the host are disorganized, and necrosis of both fungal and host cells is well advanced. D, Incompatible reaction of same genotypes 13 days after inoculation. Cross section of leaf, × 1200, showing dead vesicle (a) and extensive necrosis of host cells. The **X** reaction, not shown, combines the compatible and incompatible reactions in varying degrees in localized areas in the same leaf.

complementary activity model preserves the integrity of the unitary property about the chromosome regions involved in both genic systems conditioning functional complementarity of fit and specificity (the 1:1 ratio), and it concomitantly defines an intrinsic mechanism for variation.

The particular reactions predicted for the various degrees of complementarity of fit, as defined by the complementary activity model (Table 4), were verified by inheritance data obtained from crosses between the alleles at the *Rp* locus in maize and crosses between these alleles and the passive susceptible line B14. The phenotypic responses expressing unitary action of specificity at the *Rp* locus were sensitive to the configurational similarities of the known mutant alleles combined (see Table 3) (Lee, 1961). The reciprocal sensitivity in the pathogenic locus of *P. sorghi* for configurational control of reaction specificity towards the *Rp* locus in maize was demonstrated also from

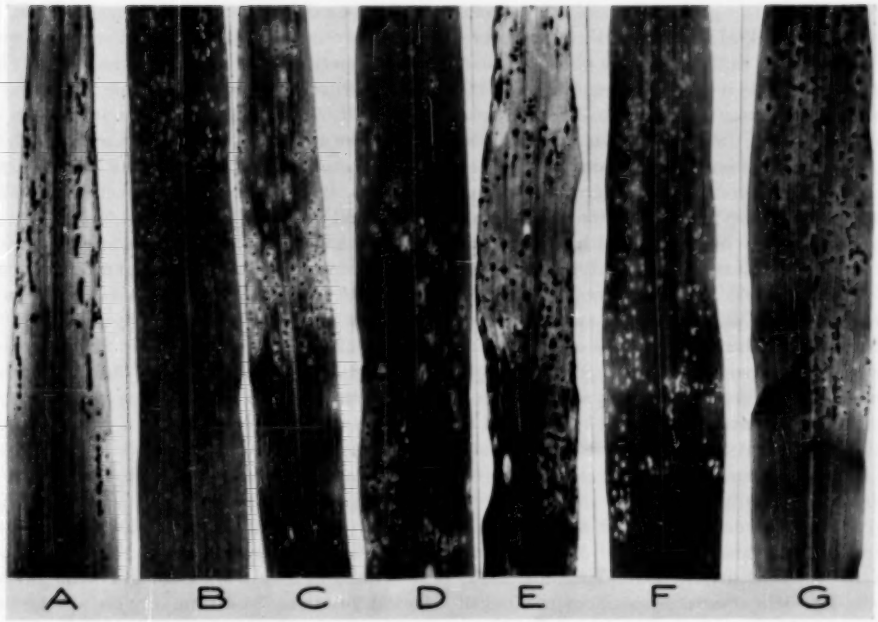


FIG. 3. UREDIAL RUST REACTIONS INCITED BY *P. sorghi* CULTURE 3-32 AND DERIVED AECIAL INBRED RECOMBINANT (SUBCULTURE) 3-32-03-13 ON THE LEAVES OF MAIZE INBRED LINES GG208R AND CUZCO, EACH OF WHICH WAS HOMOZYGOUS DOMINANT FOR RESISTANCE AT THE Rp LOCUS IN MAIZE; IN THE PASSIVE SUSCEPTIBLE INBRED LINE B14; AND IN THE SINGLE HYBRIDS B14 × GG208R, AND CUZCO × GOLDEN GLOW

The differential host allele in Golden Glow is identified as being the same as GG208R in reaction, and was derived from similar source material (Lee, 1961). A. Culture 3-32 on the GG208R inbred line; type **3-4** reaction. B. Culture 3-32 on the Cuzco inbred line; type **0;** reaction. C. Subculture 3-32-03-13 on the same Cuzco inbred line; type **2** reaction. D. Subculture 3-32-03-13 on inbred line GG208R; type **X** reaction, with a few large uredia combined with necrosis. E. Subculture 3-32-03-13 on single hybrid B14 × GG208R; **X** type reaction, approaching the susceptible reactions 3-4. F. Either culture 3-32 or subculture 3-32-03-13 on single hybrid Cuzco × Golden Glow; type **0;** reaction. Either culture 3-32 or subculture 3-32-03-13 on passive susceptible inbred line B14; type **3-4** reaction.

studies of the effect of mutation and genome interchange between anastomosed inbred dicaryons of the pathogen on the phenotypic expression of reaction (unpublished data). Derived pathogenic types were scored with various degrees of reaction specificity similar to the inbred pathogenic types recovered in Table 2. Further, pathogenic mutants derived from the same inbred dicaryon, and recovered as independent events on the same differential host line, frequently were scored as different pathogenic types. Apparently, phenotypic responses of rust uredial types delineate a genic dimension in the host on a complementary or position effect basis. These data corroborate the precision and parallel the similar genetic origin of geometric variation demonstrated to hold for the complementary locus for pathogenicity in the fungus (Flangas and Dickson, 1961). The dynamics of this fine genetic resolution of the chromosome structure, conditioning the 1:1 complementarity of fit demonstrated to relate the host and pathogen complementary genic units existing in the maize-rust system, furnishes a model for predicting a molecular basis of host and obligate-parasite interaction and phenotypic expression.

A PHYSICOCHEMICAL MODEL OF HOST-PARASITE INTERACTION AND MOLECULAR CONTROL OF SPECIFICITY

Theoretical translation of complementarity of fit of rust pathogenesis to a molecular and physicochemical basis of specificity applies the recent concept concerning the origin of chemi-

cal specification in genetic units of microorganisms (Benzer, 1957; Crick, 1957; Pontecorvo, 1958a). Implicit to the operation of this physicochemical model is an understanding of the spatial organization of genetic material in relation to function. In organisms in which the location of chromosomal mutations can be established, there is a strong suggestion that all mutations effecting the production of the same protein tend to be located within the same chromosomal region (Fincham, 1959a; Ingram, 1957; Itano, 1953; Pauling, Itano, Singer, and Wells, 1949). The theoretical application of this concept to the data obtained on the inheritance of pathogenicity and serotypes of *P. sorghi* (Flangas and Dickson, 1961), the recent data on interallelic complementation at the *Rp* locus in maize (Lee, 1961), and its correlation to the complementary activity model (see Table 4) appear biologically heuristic.

The physicochemical study of obligate specificity must be associated closely with genetic control of specificity. In maize rust, the alleles at the *Rp* locus condition specificity to lines of *P. sorghi*. Similar allelic control of specificity apparently exists in flax to races of *Malampsora lini*. Theoretically, the alternative configurations of the differential host genotypes may be functionally associated with the production of a deviate chemical substance conditioning the unitary rust reaction. The complementary genotype (reciprocal configuration) of the pathogen by a similar postulation differentiates qualitative modifications in the specific molecular deviates produced by the host genotypes, i.e., by *RR*, *Rr*, and *rr*. Recent observations on the nature of the glutamic dehydrogenase produced by interallelic complementation at the *am* locus of *Neurospora crassa* may be applied to the rust reaction. Heteroallele combinations at the *am* locus produced enzyme activity—the enzyme produced in these cases, however, is a copolymerized product, on the protein level, and not identical with the wild-type protein enzyme (Fincham, 1959b). Similar relationships are suggested by Schwartz (1960) to arise at the locus in maize for the synthesis of hybrid protein with esterase activity by heterozygotes.

The allelic control of uredial rust reactions suggests that a unique molecular deviate is produced for each *Rp* configuration in the maize host (see Table 4). These molecular deviates are expressed by the phenotypic responses **0**;, **1**, **2**, **3** , **4**, and mesothetic **X** uredial reaction types in the specific differential host genotype (Fig. 3). For example, the inbred line GG208R is pure (*RR*) for one of the four known alleles at the *Rp* locus that conditions rust reaction (Lee, 1961; Mains, 1931; Rhoades, 1935; Rhoades and Rhoades, 1939; Russell and Hooker, 1959). The guard and mesophyll cells of GG208R are not sensitive to clonal line 3-32, and only partially to inbred line c-3-32-03, and, therefore, these lines of *P. sorghi* establish a parasitic relationship, and uredia develop. In contrast, lines 3-32 and c-3-32-03 incite the necrotic fleck reaction and die on the three corn lines (Cuzco, B38, and K148) carrying the other alleles at this locus (Flangas and Dickson, 1961; Lee, 1961). Correspondingly, the known lines of the pathogen that incite the differentially compatible uredial reaction on the alleles B38 and K148 incite the necrotic fleck reaction on GG208R. The histology of all the degrees of compatible reactions are similar to those shown in Fig. 2. The physiological reactions based on oxygen uptake are similar, but vary in time and intensity of reaction. The data presented by Dickson, Syamananda, and Flangas (1959) indicate that a similar biochemical process is involved in all degrees of compatibility between host and obligate-parasite relations, with the fully compatible reaction resulting when a gradual (balanced) or fully regulated biochemical process is induced or superimposed on the metabolic patterns of the genic systems in association (Daly and Sayre, 1957). The genetic basis of the commonly occurring mesothetic (indeterminate) **X** reaction (necrotic flecks and uredia of varying size surrounded by chlorotic and necrotic areas) is explained ultimately, as in Table 4, by the balanced heterologous complementarity of fit of the two intermediate interacting genetic units controlling the expression of a single biochemical process.

The conventional approach used to establish genetic linkage maps by using independent mutant marker sites is obviously not practical for obligate parasites because of their obligate nutritional nature. The analysis of gene position at the *Rp* locus in corn is complicated also by the paucity of mutant marker sites in chromosome X. Therefore, standard genetic procedures appear impractical in the analysis of this problem.

The geometric control of obligate specificity postulated by the complementary activity model (Table 4) proposes that the genetic resolution and magnitude of the reciprocal configuration of the pathogen genotype for complementarity of fit is dependent upon and related to the biological molecule(s) predicted to control specificity. Analysis of obligate parasitism on this basis can only be brought about by determining the specific molecule(s) involved in the reaction and their genetic modes of origin, i.e., (a) whether the specific molecule(s) involved are constitutively induced by the host genotype and in their natural concentrations are (passively) essential or deleterious for survival of the parasite, or (b) whether the constitutive concentration of the specific molecule(s) involved becomes altered, i.e., repressed or induced, because of the exchange of a certain level of information necessary for their altered concentration during compatible host-parasite interaction. The dynamics of this latter alternative as a biological process of obligate specificity controlling molecular concentrations are best described and best fit the current concepts of enzyme induction and antibody formation (Jacob and Monod, 1959; Monod, 1959; Szilard, 1960).

The molecular basis of obligate parasitism is supported also from data that correlate the level of protein synthesis in detached leaves of two wheat varieties to differential alterations of the original rust reactions (Samborski, Forsyth, and Person, 1958). Characteristic of detached leaves in water are a decrease in protein, a concomitant increase in amino acids, and the accumulation of alcohol-soluble carbohydrates. Protein synthesis is promoted by increased concentrations of benzimidazole (a purine analog) on detached leaves of the two wheat varieties Khapli (differentially susceptible) and Little Club (passive susceptible). On Khapli (active susceptible), the prevention of any decrease in the amount of protein and increase of amino acids in response to benzimidazole concomitantly suppressed expression of susceptibility. The interpretation of the analytical data by the authors was that the soluble nitrogen concentration (amino acids) being utilized in protein synthesis in the detached Khapli leaves, but not in Little Club, was the limiting factor conditioning the difference in rust reaction of the two host genotypes.

Susceptibility on the basis of substrate concentration in effect describes a passive process in both wheat genotypes. The susceptibility in the detached leaves of the resistant Khapli is probably due to the lack of protein synthesis to maintain a supply of available substrate. Physiological analysis of susceptibility in maize rust, however, suggests that a similar but active process is involved in both differential susceptible and passive susceptible hosts (Dickson, Syamananda, and Flangas, 1959). Assuming that an active physiological process is incited in host-parasite interaction and that this involved the dynamics of the enzyme induction model in controlling the critical substrate concentration, then benzimidazole preserves the functional capacity of the Khapli genotype for protein synthesis and consequently directly maintains the resistant reaction. This is especially revealed inasmuch as the same active promotion of protein synthesis in the (passive) susceptible wheat genotype, Little Club, by benzimidazole, had little or no effect on the susceptibility of detached leaves. The effective concentration of the molecules promoting susceptibility in Little Club is constitutively or passively effective and noncomplementary, as predicted by Table 4. These results further suggest the molecular basis of differential susceptibility and complementarity of fit of host-parasite relations (Table 4).

Analysis of obligate parasitism apparently is possible through the processing of the biological molecules of a host's cells by methods that identify the specific molecule or molecules involved. The success of the serological approach in determining the specific antigens involved and in correlating them with specificity of pathogenicity in *P. sorghi*, as carried out by Allen, Dickson, Flangas, and Beno (1959), suggests use of the method of isolating the molecules by antiserum precipitation and the study of the genotypes by means of the genetic behavior of the serotypes produced. Preliminary tests have demonstrated antigenic specificity between biochemical differences demonstrated in the passive susceptible line B14 and differentially susceptible lines GG208R, Cuzco, and B38 by column chromatography (unpublished data). Their function as antigens compared with the antigens in the respective pathogenic and nonpathogenic lines of *P. sorghi* will determine the success of this approach to the comparative study

of antibody reactions between host and parasite genotypes. The antigen specificity of the serotypes of *P. sorghi* is demonstrated in the inbred recombinants. The correlation between these serotypes and specificity in pathogenicity is suggested, but not confirmed experimentally, in the 12 pathogenic types isolated. Cross-reactions between antigens and antisera of the host and parasite genotypes offer a means of elucidating further the serological specificity of the pathogenic types in *P. sorghi* and their serological reactions with the host alleles conditioning susceptibility.

This approach is supported by the demonstration of a cross-reaction occurring only between heterologous host antigen and parasite antisera of the pathogenic race in flax rust (Flor, Clagett, and Doubly, 1960).

A comparative study of host genotypes by means of fractionation, using column chromatography, of the protein and carbohydrate components of the corn-host leaf systems, of the passive susceptible corn line B14 and of the alleles at the *Rp* locus and the F_1 populations reveals chemical differences that may be associated with rust reaction and antigen-antisera complementarity. The use of DEAE (diethylaminoethyl-) cellulose columns has shown 8 and possibly 11 separate fractions (unpublished data). The basis of comparison is the mobility of the compounds absorbing in the ultraviolet portion of the spectrum on a column of DEAE cellulose in a continuous gradient of buffer and sodium chloride. Fractions collected in 5.0 ml aliquots were examined spectrophotometricaliy at 280 $m\mu$ and 260 $m\mu$ and the protein content calculated by the method of Warburg and Christian (1942). Significant differences have been shown between the passive susceptible line B14 and differentially susceptible alleles Cuzco, B38, and GG208R. The suitability and resolution of column chromatography for this purpose was demonstrated. The similar biochemical comparison of the fractions from the leaves of the allelle in the B38 line grown at 20°C and 24°C, where the differential susceptibility is expressed, and at 28°C, where the line is passively susceptible to lines of the pathogen, correlated the composition change to the postulated gene-controlled biochemical differences (unpublished data of Dr. James Lords, Research Associate, Department of Plant Pathology, University of Wisconsin).

CONCLUSIONS AND IMPLICATIONS OF THE ROLE OF ENZYME INDUCTION IN OBLIGATE SPECIFICITY

A complete descriptive understanding of the magnitude, structure, and function of the complementary loci involved in rust pathogenesis awaits correlation of the genetic linkage maps in both the host and pathogen genotypes. While this information is basic in determining the epigenetic level of biochemical interaction between the two genic systems, it apparently is not the only means of evaluating the biochemical systems involved. The theoretical interactions suggested in Table 4 and the 1:1 complementarity of fit demonstrated for rust pathogenesis indicate the restricted fraction or fractions of the total genotype in the pathogen that are utilized in conditioning complementarity of fit to a specific differential configuration at the *Rp* locus in the host. The direct genetic resolution of reciprocal control of specificity, as indicated by the 1:1 ratio and described by the complementary activity model (Table 4), argues that an analysis of the magnitude and configuration of the genotype for specificity will depend upon and be related to the identification of the biological molecule or molecules in the host that are predicted to condition compatibility. This is analogous to identifying the genetic function of interaction by means of the biochemical properties of a primary gene product. The use of serological techniques offers an exploratory method of identifying the critical molecules involved in conditioning interactions providing they are related directly or indirectly to those demonstrated as serotypes in the previous investigations.

The hypothesis that each gene has a primary function linked to enzyme protein synthesis represents an effective experimental guide for the analysis and establishment of correlations between gene change and enzyme change in the limited biological systems analyzed (Catcheside, 1960). The dynamics of this primary gene function within a living cell are described by the current concepts of enzyme induction (Jacob and Monod, 1959; Szilard, 1960). The induced synthesis of protein in bacteria is currently thought to be controlled by two kinds of genetic factors. Besides the structural gene which contains the genetic information determining the

structure of this particular protein, an operator or regulator gene determines the production of a specific repressor acting as a cytoplasmic message controlling the expression of the structural gene (Jacob, Schaeffer, and Wollman, 1960). From the two cases analyzed by Jacob and his associates in bacteria, it appears that whereas the structural gene, as a rule, controls the synthesis of a single protein, the regulator (operator) gene represses the synthesis of several enzymes, which although different belong to the same metabolic sequence (Jacob and Monod, 1959).

The fact that a given repressor can inhibit the synthesis of several enzymes in bacteria is accounted for by the hypothesis that the different enzyme-forming systems are not only functionally, but also structurally, associated and possess a single "lock" site (operator) able to receive cytoplasmic messages in the form of the repressor so as to switch on or off the synthesis of the whole series of enzymes (Jacob and Monod, 1959). This hypothesis is considered together with the fact that genetic determinants which control the several steps of a single biochemical sequence are often closely linked in bacteria (Demerec, 1956).

The origin of the specificity of the molecular deviates postulated to control differential susceptibility in the host on a physicochemical basis (Table 4) is tantamount to assigning to the known dominant alleles of the host a "structural gene function." The known structural differences in inheritance, allelic and nonallelic in the host and parasite respectively, and independent reciprocal control of unitary specificity in the two complementary genic systems of this host and obligate parasite system (Flangas and Dickson, 1961; Lee, 1961; Russell and Hooker, 1959), may in effect mediate a similar regulatory process involved in repression, induction, or both, of the molecular basis of obligate specificity.

The process of enzyme induction is postulated to control the expression of a balanced or fully regulated biochemical process (Szilard, 1960); a similar regulated biochemical process is needed for successful obligate parasitism (Dickson, Syamanada, and Flangas, 1959). This dynamic balance of the process of enzyme induction at the structural gene site has been defined by Szilard (1960) for the enzyme β-galactosidase and goes beyond inhibiting the formation of a repressor per se and effecting enzyme expression (induction) for a biochemical sequence. The repressor is predicted to be composed of two moieties, one, the metabolic moiety, a galactoside and the other, the *R*-moiety, a polynucleotide. The repressor is thought to reduce the rate of formation of the enzyme by combining with an enzyme molecule which is still attached to its enzyme-forming site. The "attached" enzyme molecule is repressed or is not released when the metabolic moiety of a repressor molecule reversibly combines with the controlling site of the attached enzyme molecule (and the *R*-moiety reversibly combines with the purine and pyrimidine base of the enzyme-forming site itself). The reversibly dynamic balance between *R*-moieties (polynucleotides) and the enzyme-forming sites in the enzyme induction process is strengthened by a recent experiment that shows that a bacterial gene which is responsible for the repression of the enzyme β-galactosidase may exert this effect not by causing the synthesis of an enzyme, but rather by causing the synthesis of a molecule which is not a protein. This finding is consistent with the notion that a gene might cause the formation of the *R*-moiety of the repressor of β-galactosidase and that this *R*-moiety might be a polynucleotide (Szilard, 1960).

The refinement of Szilard's model of enzyme induction remains to be validated. Szilard separates the function and the origin of specificity of a repressor molecule at the controlling site. The repressor molecule is effective for repression of a specific enzyme only when complete with a specific *R*-moiety. The significance of the *R*-moiety of the repressor molecule in Szilard's study suggests a similar reaction for establishing the phenomenon of enzyme induction as the process of obligate specificity. It has long been known from histological and cytological investigations of compatible rust-host obligate parasite relations that parasitic establishment involves the intimate association of the host nucleus and fungus haustorium of the infected cells (Allen, 1923a, b; D'Oliveira, 1938; Savile, 1939; and others). Again, a possible role of polynucleotide (RNA) activity in the infected cell is suggested (Person, 1960; Savile, 1939).

The analogy made between the host alleles for resistance and the pathogenic locus in the fungus for the "structural genes" and "regulator

genes," respectively, need not limit the regulatory role of the complementary locus in the pathogen to the production of "complete" repressor molecules. The regulator role of the pathogenic genotype may rest upon the production of specific soluble polynucleotides (Person, 1960) conditioning the function of specific repressor molecules (constitutive) in the host for internal control of production of constitutive enzyme protein. The additive relationships or the differential effects of the "hybrid" and "normal" complete repressor molecules produced by the infected cells (active concentrations) competing for the specific controlling sites of enzyme formation (Szilard, 1960) could ultimately control the efficiency of specific enzyme formation, the effective concentrations, or both. Compatibility (also implied by the physiological data, above) emerges as an epigenetic or superimposed function of host-parasite interaction on the metabolic patterns of both the host and parasite. Compatibility is induced when the concentration of the molecular species conditioning the degree of complementarity of fit has been established (regulated) by primary information from the interacting genic systems.

The parasite has at least a two-dimensional adaptive stress imposed for compatible host-parasite relations, the competence to regulate as well as to utilize the molecular deviates produced by the host (see Tables 2 and 3) in the metabolic pattern for balanced or unbalanced complementarity of fit (Table 4). The genetic approach to the physiology of parasitism in the maize-rust system (Dickson, Syamananda, and Flangas, 1959) suggested that the pathogenic types of Table 2 regulated quantitatively the expression of an induced active physiological process originating from the alleles for resistance at the *Rp* locus for all degrees of compatibility. The contrast between the necrotic-fleck and fully compatible reactions lies mainly in the rate of initial oxygen uptake. The physiological data presented indicate that the fully compatible reaction resulted when a gradual (balanced) or fully regulated biochemical process is induced into the metabolic patterns of both genic systems in association.

Infection by other fungi causing rust diseases results in similar characteristic alterations in rates of respiration and a shift in metabolism which is indicated by a drop in carbon 6/carbon 1 ratios (Daly, Bell, and Krupa, 1961). In the highly investigated case of the respiratory metabolism of the safflower rust system (Daly and Sayre, 1957), the increase in respiratory rates was associated with an induced pentose pathway and was assumed responsible for the lowering of the C_6/C_1 ratio, since it was the only pathway demonstrated in plants which would result in a change in the ratio, lack of sodium fluoride inhibition, and inhibition of the Pasteur effect. More recently, however, Daly, Bell, and Krupka (1961), have demonstrated that neither the Pasteur effect nor sodium fluoride inhibition is sufficiently consistent to describe the respiratory pathway induced by infection. In any event, they conclude that their data clearly show that an abrupt shift in the type of respiratory metabolism occurs after the respiratory apparatus has been geared to a higher rate. They also concluded that whether this is directly related to, and required for, sporulation (susceptible reaction type) will be answered only after more basic information on the induction mechanism and on the kinetics of the abrupt transformation to a lower C_6/C_1 ratio is known.

The induction mechanism and triggering sites for the kinetic complexities involved in compatible host-parasite relations are suitably explained theoretically by the enzyme induction model through controlling effective molecular concentrations for complementarity of fit (Table 4). Implicit to the "structural gene" concept of the genotypes of the active and passive susceptible hosts at the *Rp* locus described in Table 4 is the simultaneous development of a "lock" site mechanism (Jacob and Monod, 1959) in active susceptibility. The "structural gene" locus (*RR* or *Rr*) of active susceptible genotypes (Table 4) is differential not only for production of mutant deviate molecules (such as *RR*, *R'R'*, *RR'*, *Rr*, or *R'r*, see Table 3) but also through concomitant development of a "lock" site mechanism that is differentially sensitive (specific) to information from the genetic configurations of the pathogen *AA*, *Aa*, or *aa*, and which may interfere with the controlling of the specific internal constitutive molecular functions of these deviate molecules in a single biochemical sequence (Jacob and Monod, 1959). The genotypes (*rr*) of the passively susceptible hosts P39 and B14 (Tables 3 and 4) are assumed to lack the "lock" site mechanism which is differentially

specific to balanced or unbalanced interference by specific information (products) from the pathogenic genotypes *AA*, *Aa*, and *aa*. This intrinsic capacity or flexibility of the pathogenic genotype of the parasite is well emphasized by the demonstrated indeterminate (nonallelic) inheritance of pathogenicity towards the alleles for resistance at the *Rp* locus in the maize-rust system (Flangas and Dickson, 1961).

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NEW BIOLOGICAL BOOKS

The aim of this department is to give the reader brief indications of the character, the content, and the value of new books in the various fields of Biology. In addition there will occasionally appear one longer critical review of a book of special significance. Authors and publishers of biological books should bear in mind that THE QUARTERLY REVIEW OF BIOLOGY *can notice in this department only such books as come to the office of the editor. The absence of a book, therefore, from the following and subsequent lists only means that we have not received it. All material for notice in this department should be addressed to H. B. Glass, Editor of* THE QUARTERLY REVIEW OF BIOLOGY, *Department of Biology, The Johns Hopkins University, Baltimore 18, Maryland, U. S. A.*

THE STATUS OF WARBURG'S THEORY OF GLYCOLYSIS AND RESPIRATION IN TUMORS

BY SIDNEY P. COLOWICK

Vanderbilt University

A Review of THE GLYCOLYSIS AND RESPIRATION OF TUMORS.

By Alan C. Aisenberg. Academic Press, New York and London. $8.00. xiv + 224 pp.; ill. 1960.

This book presents a thoughtful summary of research on the metabolic energy sources for tumors. It will undoubtedly serve as a valuable reference work, since it contains 71 well-selected tables of data covering the major contributions in the field. Of particular value are the compilations on the respiratory and glycolytic activity of a large number of normal and tumor tissues of animals and humans. There are in the entire book 538 references covering the English literature up to 1959. The author in his preface confesses that his coverage of the non-English literature is weak. Fortunately, the major works of Otto Warburg, who was the creator of this field of investigation, have been translated into English, and the bulk of modern work in the field has been published in English, so that the book remains reasonably comprehensive.

In view of the fact that this is a field noted for the emotional disputes which it can engender between those holding opposing views, Aisenberg has shown remarkable objectivity in presenting all of the conflicting evidence concerning each question considered. The disturbing result of this type of presentation, however, is that practically every major question raised remains unsettled. Aisenberg cannot be blamed for this state of affairs, which points up the need for more basic work in this area. In what follows, I shall attempt to review the present state of the field, following more or less the order used for presentation in the book.

Part I: The Anaerobic and Aerobic Glycolysis of Normal and Tumor Tissues. The generalization by Otto Warburg that all tumors show a high rate of glycolysis anaerobically is supported by the data presented ($Q_{CO_2}^{N_2}$ is almost always greater than 10 and may attain 80 when pure tumor cells, such as are found in ascites tumors, are tested). Warburg's further generalization that tumor cells are unique in exhibiting substantial glycolysis under aerobic conditions is almost entirely borne out by the data, but there are a few exceptions, i.e. normal tissues which also exhibit aerobic glycolysis. These include retina, leukocytes, kidney medulla, and jejunum mucous membrane. Warburg has always maintained that aerobic glycolysis by normal tissues would not occur in vivo, but that it might arise due to damage during removal or due to measurement in a non-physiological environment. Aisenberg fails to mention Warburg's recent work showing that the leukocytes do not exhibit aerobic glycolysis until they are removed from their normal serum environment, just as he had shown previously for embryonic tissues.

Data are presented to show that the transformation to malignancy, either by treatment with a carcinogen or in the case of a spontaneous tumor, is accompanied by a marked increase in both anaerobic and aerobic glycolysis over that of the tissue of origin. However, the author does not stress sufficiently the difficulty in assessing which cell type in the normal tissue was actually the source of the tumor. It is only when a pure clone of normal cells of one type gives rise to a tumor that one can assess the actual metabolic change accompanying the induction of malignancy. That is why such importance must be attached to the report of Burk that a malignant cell line derived from a pure clone of heart fibroblasts in cell culture showed greater glycolytic

activity than a non-malignant cell line derived from the same clone.

The fact that even non-malignant cells, particularly those of embryonic origin, when propagated in vitro, show pronounced aerobic glycolysis has led some workers to the view that aerobic glycolysis is simply a characteristic of rapidly growing cells. The little-known experiments of R. J. O'Connor, not cited by Aisenberg, showed that aerobic glycolysis in chick embryo midbrain at various stages was strictly correlated with the mitotic index. One must point out, however, that O'Connor's measurements were not made in a serum medium. Furthermore, as Aisenberg illustrates, rapidly regenerating liver tissue does not show glycolysis.

Aisenberg reviews well the enzymology of glycolysis and the factors controlling glycolysis in tissue extracts. However, there are no clues here as to whether changes in content of certain glycolytic enzymes may be characteristic of the induction of malignancy. The data of Wu and Racker, on the content of glycolytic enzymes in a variety of normal and tumor cells, are not included. However, even these data suffer from the fact that no comparison is yet available of the enzyme content of a tumor cell and that of the normal cell of origin.

The occurrence of glycolytic enzymes in the serum of tumor-bearing animals is reviewed. The original view of Warburg was that these enzymes were derived, not from the tumor, but from tumor-induced break-down of normal muscle tissue. This view is now modified to include some contribution from the tumor itself to the enzyme content of the serum. The diagnostic value of this phenomenon is limited, since other diseases can give rise to similar changes in serum enzymes. However, the phenomenon of the action of tumors at a distance on host tissue enzymes is possibly an important factor in explaining the invasiveness of tumors as well as their well-known effect in causing wastage of tissue in the face of adequate nutrition.

Part II. The Oxidative Metabolism of Tumors. The major reason that so much work has been done on the oxidative metabolism of tumors is that there is general agreement that aerobic glycolysis is a consequence of inadequate respiration *relative to* the high rate of anaerobic glycolysis. The view presented by Aisenberg is the one generally held, namely, that tumors exhibit a normal Pasteur effect, as measured by the extent of suppression of glycolysis per mole of oxygen consumed, and that they simply have such high anaerobic glycolytic activity that the amount of oxygen consumed is inadequate to suppress the glycolysis completely. I feel, however, that the Pasteur effect in tumors may be less efficient than in normal tissues. One must recall that in most normal tissues, oxygen suppresses the glycolysis *completely*. Under these conditions, the efficiency of suppression of glycolysis must be underestimated. Thus, as Warburg has suggested, it may be the "quality" rather than the quantity of the respiration which is inadequate in tumor tissue.

The "quality" of respiration can be measured by the efficiency of adenosine triphosphate (ATP) synthesis (P:O ratio). When this ratio is measured in homogenates of certain tumors, it is characteristically very low because of the presence of a microsomal adenosine triphosphatase (ATP-ase) which represents an abnormally high fraction of the total ATP-ase activity. This phenomenon has been rather neglected, since it has been found that good P:O ratios can be obtained either by suppressing the ATP-ase activity with fluoride or by working with microsome-free mitochondria.

It seems to me that there may be a basic fallacy in the view that the "proper" study of tumor homogenates requires fortifying them to produce optimal conditions for oxidative phosphorylation or respiration. The defects observed in non-fortified homogenates deserve more consideration. Another case in point is the study of Potter some years ago which showed that tumor homogenates failed to show the first step reaction of the Krebs citric acid cycle, namely, oxaloacetate utilization to form citrate. When Weinhouse showed that homogenates fortified with diphosphopyridine nucleotide (DPN) were perfectly capable of oxidizing oxaloacetate, interest in the Potter phenomenon faded. However, as Aisenberg points out, the reason why tumor homogenates should require fortification with DPN is far from understood and may provide a clue to some basic difference in the tumor cell.

It is a remarkable fact that the Potter phenomenon can also be demonstrated in tumor-bearing animals in vivo. Aisenberg documents this, not only with data on the failure of citrate to accumulate in tumors of fluoroacetate-poisoned animals, but also with studies showing failure of labeled acetate or pyruvate to give rise to appreciable amounts of labeled Krebs cycle intermediates in the tumors. The puzzling fact remains, however, that when tumor slices are studied, these processes are readily demonstrated. Aisenberg prefers to accept the latter finding and to discount both the homogenate and the in vivo results.

Unquestionably, the most controversial issue in this field is the Warburg theory regarding the origin of the tumor cell. According to this theory, tumors arise because of damage to the respiration (mitochondria) of normal tissues, and survival depends upon the ability of the cell to make up for its respiratory deficit by deriving energy from glycolysis.

This view has been challenged by Weinhouse, on the basis that this theory requires that the absolute

Q_{O_2} values for tumors be lower than those for normal tissues. The data available indicate that tumor respiration falls within the wide range of normal values. However, one is faced with the aforementioned difficulty in deciding which normal cell type gave rise to any given tumor. In Burk's experiment, mentioned above, the malignant cell line showed a lower Q_{O_2} than the benign cell line derived from the same clone. Aisenberg dismisses the view that tumors have a low Q_{O_2} and indicates that Warburg fell into error in this respect because the first few tumors examined by him some 40 years ago happened to have a low respiration.

However, the idea of a damaged respiration cannot be dismissed so lightly. Aisenberg points to a considerable body of evidence that the content of mitochondrial nitrogen per gram of tumer cells is much lower than in normal cells, and cites the results of Wenner and Weinhouse on the parallel lowering of pyruvate oxidation capacity per gram of tissue. There thus exists a real problem which Aisenberg fails to consider, and that is how the Q_{O_2} of tumors can be in the normal range while at the same time their content of mitochondrial protein is far below normal. Studies on mitochondrial counts are rather ambiguously reported, but do not always appear to show the drop found in mitochondrial nitrogen. This suggests a qualitative change in the mitochondria accompanying tumor induction, a possibility borne out by studies of Hogeboom and Schneider showing the altered protein pattern in extracts of tumor mitochondria. Other studies show, furthermore, a very low content of certain oxidative enzymes (succinic dehydrogenase, cytochrome oxidase, and cytochrome c) per mg of mitochondrial nitrogen, a situation which would suggest even greater damage to mitochondrial respiration.

Aisenberg tends to discount the evidence for damaged respiration and to prefer Chance's view that tumor mitochondria are normal in respect to cytochrome content and oxidative capacity, but show limited respiration in the cell because of an absence of phosphate acceptor. He emphasizes the finding of Monier et al. that there is no lack of cytochrome c relative to other members of the cytochrome system, while minimizing their finding that the other cytochromes were very low or were lacking in ascites tumor cells.

In addition to denying that tumors exhibit a damaged respiration, Aisenberg attempts to refute Warburg's theory on the origin of the cancer cell on the following grounds:

(1) He points out that many carcinogens are not inhibitors of respiration. However, he then sites the work of R. Kielly which showed a correlation between the carcinogenic activity of a certain series of aminofluorene dyes and their ability to inhibit glutamate oxidation by mitochondria.

(2) He points out that the highest concentration of protein-bound carcinogen is present in cytoplasm, but admits that mitochondria also take up carcinogenic dyes. In fact, at this point he cites Potter's view that the specific lesion in tumors may be due to the deletion of mitochondria rather than soluble enzymes.

(3) He doubts that induction of tumors by X-rays should be attributed to damage of mitochondrial respiration, in view of established effects of X-rays on nuclear morphology. It is not clear, however, why the latter effects could not be cytoplasm-mediated.

(4) He doubts the interpretation of the experiment of Goldblatt and Cameron, who produced a malignant population of cells by exposing fibroblasts in tissue culture to intermittent anoxia. His statement that malignancy can be produced in culture without anaerobiosis does not, however, rule out the possibility that anaerobiosis, too, can lead to malignancy.

Aisenberg concludes that the Warburg hypothesis merits further study and that "although at the present time a body of significant scientific data in support of Warburg's views does not exist, it must not be forgotten that the intuition of an outstanding mind may grasp a phenomenon beyond the reach of experimental verification and beyond the general understanding of the time. Eventually such intuition is translated into scientific proof."

The details of the oxidative metabolism of tumors are given rather thorough consideration. The main conclusions are as follows. Tumors without added carbohydrate oxidize fats. With added carbohydrate they show a diminished respiration (Crabtree effect) and a partial replacement of the fat oxidation by carbohydrate oxidation.

A striking feature of tumors is that they fail to produce carbohydrate from non-carbohydrate sources. In line with this, there is a lack of two enzymes normally associated with gluconeogenesis, namely fructose diphosphatase and glucose-6-phosphatase. This lack of gluconeogenesis would account in part for the need for carbohydrate for tumor cells to grow in culture. The work of Eagle, of Puck, and of Liebermann on the requirements for growth of tumor cells in culture is unfortunately not considered at all in this book.

Aisenberg quotes Nirenberg's work relating absence of tumor glycogen to absence of glycogen phosphorylase. The implication that a low glycogen level is due to low phosphorylase activity is no longer acceptable, since glycogen synthesis is now known from Leloir's work to proceed by means of another enzyme, uridine diphosphoglucose (UDPG) —glycogen glucosyl transferase. The work of Wu and Racker showing that the latter enzyme is func-

tional in HeLa cells making glycogen, is not covered.

Aisenberg alludes briefly to the low "DPNH oxidase" activity of tumor homogenates. However, he does not discuss the currently accepted mechanism for oxidation of cytoplasmic DPNH by mitochondria via the "glycerophosphate shuttle." The recent finding by Sacktor of diminished α-glycerophosphate dehydrogenase correlated with an increased glycolytic activity of leukemic cells, suggests that the lowered "shuttle" activity may help account for the lowered respiratory activity of tumors.

The synthesis of fat from carbohydrate is very slow in tumors, according to Medes and Weinhouse, who suggest that tumors must obtain preformed lipids from the host. This would be in line with the low α-glycerophosphate dehydrogenase activity of tumors, which would limit α-glycerophosphate synthesis.

Oxidation of carbohydrate and fat proceeds via the Krebs cycle enzymes, which are all present in tumors, although aconitase and α-ketoglutaric oxidase are present in low concentrations. The enzymes of the hexose monophosphate shunt are present in "normal" amounts, but the quantitative significance of the pathway seems to vary from one tumor to another. In some tumors it accounts for a large enough fraction of the total respiration that it may, it seems to me, influence adversely the efficiency of ATP synthesis (P:O ratio), since reduced triphosphopyridine nucleotide (TPNH) oxidation is not coupled with phosphorylation.

Aisenberg does not refer to Wenner's finding of the increased oxidation of the C_1 atom of glucose in tumors when pyruvate is added. This finding is possibly of interest in providing a role for lactic dehydrogenase in the maintenance of the shunt pathway.

Part III. Regulatory Mechanisms in Respiration and Glycolysis. This section deals very clearly with a complex subject. The various theories of the Pasteur effect are concisely presented. The present picture is based on the original views of Marvin Johnson and of Feodor Lynen, that oxygen suppresses fermentation by limiting the concentration of phosphate and phosphate acceptor needed to maintain triose phosphate oxidation. In order to explain the suppression of glucose phosphorylation, Lynen, Chance, and Racker have all proposed a compartmentalization of oxidatively synthesized ATP such as to make it unavailable for glucose phosphorylation.

Aisenberg points out that the Crabtree effect (the inhibition of respiration by glycolysis), while governed by essentially the same principles as above, operates with greater efficiency than the Pasteur effect, i.e., that the suppression of respiration is balanced exactly by the increase of glycolysis in terms of energy available to the cell.

The Crabtree effect is observed, of course, only in cells exhibiting aerobic glycolysis. One puzzling fact is that the adult retina, with one of the highest known rates of aerobic glycolysis, exhibits no Crabtree effect. The final solution to the Crabtree phenomenon must account for this fact.

Part IV. The Dependence of Tumors on Oxidative and Glycolytic Energy. Aisenberg cites experiments showing that amino acid incorporation into tumor protein can occur anaerobically provided that glucose is present, and that this incorporation is just as efficient as aerobic incorporation. Similar data are available for P^{32} incorporation.

These studies add support to Warburg's view that tumors can depend upon glycolysis for part of their energy supply. In Aisenberg's summary he makes a plea for consideration of this point of view in seeking new approaches to the chemotherapy of cancer. He suggests that tumor cells may be particularly sensitive to attack upon either their respiratory or glycolytic sources of energy supply. I agree particularly with the desirability of seeking specific inhibitors of the glycolytic process, which may be uniquely required for the survival of tumor cells. Even if one should find that glycolysis is a general property of growing cells, this approach to chemotherapy would remain as sound as the current approach of interfering with DNA synthesis, which certainly is not specific for tumors. The latter approach has nevertheless proved fruitful, and it is conceivable that a combined attack on glycolysis and DNA synthesis might prove even more effective.

In this review, I have attempted to sum up the major conclusions as well as the major questions remaining at issue in this field. Clearly, the latter still outnumber the former. Aisenberg has performed a much-needed task in bringing together so much of the pertinent data.

[It is perhaps inevitable that errors will creep in when data are being transcribed. The following errors were found in the tables:

p. 37, Table 9. For "micromoles per gram," read "micromoles per 100 grams."

p. 73, Table 24. For "net weight," read "wet weight."

p. 75, Table 27. In last column, for "+ 2.0" read "trace."

p. 79, Table 29. In last column, for 2.460, 1.225, 1.000, and 1.750, read 2,460, 1,225, 1,000, and 1,750.

p. 98, Table 39. For "milligrams per gram," read "micrograms per gram."

p. 105, Table 42. Third and fifth columns have same heading.

p. 147, Table 61. Values for biotin 1000-fold too high.

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GENERAL BIOLOGY: PHILOSOPHY AND EDUCATION

NATURE AND MAN'S FATE.

By Garrett Hardin. Rinehart & Company, New York and Toronto. $6.00. xiv + 375 pp.; ill. 1959.

There are some books one skims quickly for pleasure and others that must be plowed manfully for information. *Nature and Man's Fate* is neither of these. Highly thought-provoking, it is nevertheless written, as Garrett Hardin so excels in doing, in a clear and entertaining style that belies its profundity and scientific soundness.

The subject of the volume is the current status of genetic and evolutionary theory, with all soundly conceivable implications for the future of mankind. Besides grappling with such time-honored problems as the relation of Darwinism to Deity, Hardin analyzes the question of whether there is progress in evolution, probes the relation of genetics to determinism and to individual uniqueness, treads gently through the snares and bogs of eugenics, and ends with an essay "In Praise of Waste."

One need not expect to agree with him in everything. Especially in the last chapter, and in discussing social aspects and outcomes of biological and evolutionary processes, there seems to be a tendency on the part of the author to over-generalize or to make unwarranted analogies. Perhaps this is the inescapable result of his effort to be not only clear but to be also forceful and graphic in style. Let us take an example. In discussing the topic "One World—or Many?" Hardin describes the "noble dream" espoused by so many of the 'best' elements of our society and opposed by so many who are intolerant or ignorant. And then he says: "Yet a biologist, however much he may dislike the complexion of this group, can hardly throw in his lot with the opposing camp, those who think that One World is both possible and the best of all possible worlds." This sentence, however, is out of context, and the subsequent discussion shows that the author here means "One World" only in a very special sense—perhaps not at all the sense in which any of its advocates would mean it. He means a "competition-free world"—it is this which is impossible! Who indeed would dispute it? What advocates of "One World" mean by their dream is political unity, or perhaps racial unity, or perhaps religious unity—none of these in the sense of a disappearance of differences of ideology, color, or credo, but simply in the sense of the development of means and an organization that will make possible, in every instance when disputes and divergences of aim arise, a peaceful and orderly resolution. But in this accepted sense Hardin evidently joins, since he says, "Certainly it [One World] is possible in a political sense." Nevertheless, he concludes this discussion with some generalizations which seem very dubious to me, and unsupported by solid facts, e.g., "Genuine tolerance of human variety has been strongest in frontier situations, where men competed with Nature rather than with other men," and "Diversity within the species demands isolation of populations—many worlds, not one." Is it true that savages consistently show a greater toleration of human variety than civilized men? Was tribal warfare not the common experience of primitive man? Do men on the frontier really compete with Nature more than with other men? Is it not true that coalescence of populations only temporarily reduces genetic variety, and that in Wright's models variation shifts from predominant differences between populations to predominant differences between individuals belonging to the same population? The small, inbred isolate is more homogeneous than the large population. In any case, can one be sure that the biological analogy applies to the social evolution of man?

Other readers may find other parts of the discussion with which to differ. Yet of one thing we may be sure—no reader who peruses this book thoughtfully and carefully will fail to garner a harvest of valuable thought. The striking diagrams, in style resembling those in the author's *Biology*, add to the lucidity with which the chosen subjects are treated. All in all, this is a book which guarantees not only a pleasant and stimulating first reading, but is one to which the reader will often want

to return. It is in the great tradition of H. S. Jennings' *The Biological Basis of Human Nature*, J. B. S. Haldane's *Heredity and Politics*, and Th. Dobzhansky's *Evolution, Genetics, and Man*.

BENTLEY GLASS

THE LIVING LABORATORY. *200 Experiments for Amateur Biologists.*

By James Donald Witherspoon and Rebecca Hutton Witherspoon; illustrated by the authors. Doubleday & Company, Garden City. $3.95. 256 pp.; ill. 1960.

The first part of this book gives directions for maintaining cultures and for experimenting with protozoa, hydra, planaria, and insects. The next section deals with background information and the care of vertebrates. This is followed by sections on nerves and the brain; special senses; the skeleton, muscles, and energy; digestion and nutrition; heart, circulation, and the lungs. The authors give clear, concise basic information under each of the above topics. They also suggest numerous experiments, some of them surgical, on living animals, and some harmless experiments on human beings. The appendices contain much helpful information such as relates to the care and handling of frogs and mice, the addresses of biological supply houses, and national fair regulations for experiments with animals.

The book gives clear directions for many interesting experiments with animals. Many of these experiments can be performed independently by high school students, but those with live vertebrates will require supervision by a trained, qualified adult.

MARY DEMEREC

BIOLOGY: HISTORY AND BIOGRAPHY

THE DEATH OF ADAM. *Evolution and Its Impact on Western Thought.*

By John C. Greene. Iowa State University Press, Ames. $4.95. xii + 388 pp.; ill. 1959; *New American Library, New York.* Seventy-five cents (paper). 382 pp.; ill. 1961.

Among the books of the Darwin centennial, two stand out in literary excellence combined with sterling scholarship. Both are devoted to the history of ideas, the gradual progression of thought that led to Darwin's monumental achievement. One is Loren Eiseley's highly praised survey of *Darwin's Century*. The other is the present work.

It would be hard to acclaim too greatly the fine qualities of John C. Greene's book. Its eminent readability is matched by the author's breadth of treatment and perspective. Sweeping over a much larger canvas than Eiseley attempts to cover, he begins with the work and ideas of John Ray, whose desire to set forth the "Wisdom of God Manifested in the Works of the Creation" came into conflict with "mechanick theists" and yet was embarrassed by his own discoveries. Greene traces the genesis of modern astronomy, geology, biology, anthropology, and paleontology, sets forth in considerable detail the ideological conflicts about the Creation during the early nineteenth century, and completes his study with chapters on Darwin and his friends Lyell and Huxley. The impact of the theory of evolution on religious thinking is a central theme, leading at length to our present dilemma: "Man's increasing mastery of nature did not imply his increasing mastery of himself. To the very end man remained the creature as well as the creator of human progress. Every step upward in the knowledge and control of nature augmented his power for evil along with his power for good.... The historical Adam is dead, a casualty of scientific progress, but the Adam in whom all men die lives on, the creature and creator of history, a moral being whose every intellectual triumph is at once a temptation to evil and a power for good."

Neo-Darwinians and eugenists, who see only a roseate future of human evolutionary progress, will not be pleased at this ending. Yet can anyone look upon man's disastrous feuds and frenzies and not believe his high achievements and his birthright endangered? Let every biologist read and take pride in the growth of his science, which brought about the "death of Adam"; let him discern his own roots and see his own handiwork in the setting of human history; let him soberly give thought to the survival of the human spirit in the cold white light of evolution and our knowledge of man's origins. To this historian and humanist we owe an undying debt.

BENTLEY GLASS

SOME EIGHTEENTH CENTURY BIRD PAINTINGS IN THE LIBRARY OF SIR JOSEPH BANKS (1743–1820). *Bull. Brit. Museum, Vol. 1, No. 5.*

By Averil Lysaght. The British Museum (Natural History), London. £2 (paper). ii + pp. 253-371 + 3 pl. 1959.

For the most part, this is a catalog of the bird paintings assembled by Sir Joseph Banks from the first, second, and third voyages of Sir James Cook, from J. C. Phipps's voyage toward the North Pole in 1773, and some paintings made at the Cape of Good Hope in 1772–76. The monograph includes biographical sketches of the several painters, as well as of Sir Joseph Banks himself. Appendices list the birds collected by Banks in Newfoundland and Labrador in 1766, an index to the birds described by Solander on Cook's first voyage, and a chronicle of Cook's itineraries. There is a full taxonomic index. The three plates figured make one wish there had been a far more extensive representation of the collection.

A Short Introduction to Anatomy (Isagogae Breves).

By Jacopo Berengario da Carpi; translated with an introduction and historical notes by L. R. Lind; anatomical notes by Paul G. Roofe. The University of Chicago Press, Chicago. $5.00. xii + 228 pp.; ill. 1959.

Berengario da Carpi's *Isagogae Breves*, of 1523, fills the gap in the development of anatomy between the *Anatomy* of Mundinus and the *Epitome* of Vesalius, the translation of which by L. R. Lind is well-known. This volume, in which the translation of the 1523 edition is accompanied by reproductions of the original woodcuts, translator's notes, and anatomical notes provided by Paul G. Roofe, is a valuable addition to medical and anatomical history. There is also a bibliography of Carpi's works and an anatomical index.

A Prelude to Medical History.

By Félix Martí-Ibáñez. MD Publications, New York. $5.75. xxiv + 253 pp. 1961.

The author of this book is Professor of the History of Medicine at the New York Medical College, Flower and Fifth Avenue Hospitals in New York City. He describes his *Prelude* . . . as "just a notebook of medical history, an outline of the history of medicine seen through the enthusiastic wonder-filled eyes of a restless world-wandering physician whose heart, as he marches on to his rendezvous with History beats as happily and eagerly as the heart of a medical student on his way to rendezvous with his sweetheart." There is little this reviewer can add to the author's description except to suggest that the book merits a place on a bedside table.

Morris C. Leikind

THE YOUNG NATURALIST

Men, Ants, & Elephants: *Size in the Animal World.*

By Peter K. Weyl; illustrated by Anthony Ravielli. The Viking Press, New York. $3.00. 103 pp.; ill. 1959.

In this very interesting volume the author describes the range in size of living things. He touches upon the early units of measure and the length-area-volume relationship. The major part of the book is devoted to a discussion of the effect of size on the ability of living creatures to do things, on their ability to hear and see, on the strength of their bodies, and on their body temperatures. The author concludes that "we are what we are because of the size we are. If we were much larger we would be much too clumsy to lead an active life. . . . The wonderful world we live in obeys the laws of size which we are able to contemplate and understand because we are the size we are."

The book will appeal to boys and girls of junior and senior high school age.

Mary Demerec

Strange Partners.

By Sigmund A. Lavine; illustrated by Gloria Stevens. Little, Brown & Company, Boston and Toronto. $2.75. xiv + 106 pp.; ill. 1959.

The author describes many interesting partnerships encountered in nature. The book is well written and holds the interest of the reader as he journeys with the author from the sun-baked veldt of Africa to the frozen muskeg swamps of the Arctic and observes the fascinating phenomenon of symbiosis.

Unfortunately the author occasionally makes such statements as, "Blossoms choose their partners with great care." Nevertheless, the book provides good reading because it covers a fascinating subject in a very interesting manner.

Mary Demerec

Watch The Tides.

By David Greenhood; illustrated by Jane Castle. Holiday House, New York. $2.75. vi + 36 pp.; ill. 1961.

This is an appealing and attractive book about the changing tides and their effects on the shore and on the living things within their reach. Although the format is almost that of a primary picture book, the language and the information the book contains are appropriate for somewhat older children. The illustrations are delightful, skilfully combining factual material with the beauty of the salt marsh, breaking waves, and seashore fauna and flora.

This book should have special appeal for the middle grade child whose interests in nature have somewhat outstripped his present reading level. It would certainly be a welcome addition to any elementary school library.

Mary Demerec

All About Undersea Exploration.

By Ruth Brindze. Random House, New York. $1.95. vi + 145 pp.; ill. 1960.

This account of the world beneath the sea reads like an adventure story. The first part tells about the work of oceanographers at sea, Scuba and helmet divers, descent to the sea floor by bathysphere and bathyscaphe, and the latest undersea explorations by the atomic submarine. The second part includes fascinating stories of the raising of archeological treasures and gold from the bottom of the sea, underwater photography, prospecting and drilling for oil under water, and the laying of transatlantic cables.

This book will appeal to children beginning at the age of ten.

Mary Demerec

CHRISTMAS TREES *and How They Grow.*

By Glenn O. Blough; illustrated by Jeanne Bendick. Whittlesey House, McGraw-Hill Book Company, New York, Toronto, and London. $2.75. 48 pp.; ill. 1961.

Behind the simple title of this children's book lies a very considerable amount of information on Christmas trees and on trees in general. The book opens with the story of a family selecting a Christmas tree in the woods. It then considers, in simplified and well-illustrated fashion, just how and where trees grow and what they are used for, and closes with a section on Christmas tree festivities in our country. The author writes clearly and simply, and does not hesitate to use such words as carbon dioxide and chlorophyll, where appropriate. His book should be a suitable Christmas present for the 8–12 year old child.

ANNETTE COLEMAN

WHO LIVES IN THIS MEADOW? *A Story of Animal Life.*

By Glenn O. Blough; illustrated by Jeanne Bendick. Whittlesey House, McGraw-Hill Book Company, New York, Toronto, and London. $2.50. 48 pp.; ill. 1961.

This is an excellent book which demonstrates the author's competence in his field and his knowledge of how the concept of animal adaptation can be made interesting and understandable to children. A child who has read this book will be helped in finding and observing many fascinating animals in his own environment. The illustrations are clear, very effective, beautifully designed, and will appeal to children and adults alike. Older children will enjoy reading it, and younger ones will enjoy having it read to them.

MARY DEMEREC

ZOO CELEBRITIES.

By William Bridges; photographs by Sam Dunton. William Morrow & Company, New York. $2.95. 127 pp.; ill. 1959.

This is another of William Bridges' delightful books dealing with animals in the Bronx Zoo. It is entertaining and extremely readable, either silently or orally, and yet it manages to give a generous amount of information about the animals themselves, the inner workings of a large zoological park, and the character and responsibilities of the various humans involved in the care of the animals. The book should be greatly enjoyed by any child of the middle elementary grades and lends itself to reading aloud at almost any grade level. It will appeal especially to those children interested in animals in general or those thinking of careers involving work with animals.

MARY DEMEREC

ECOLOGY AND NATURAL HISTORY

A MIDWESTERN ALMANAC. *Pageant of the Seasons. By Austin L. Rand and Rheua M. Rand; illustrations by Ruth Ingeborg Andris. The Ronald Press Company, New York.* $4.50. vi + 176 pp.; ill. 1961.

This is a personal calendar of the seasons as they come and go in the vicinity of Chicago, this vicinity extending as far west as Minnesota and Iowa and as far east as Lake Erie, but concentrated mainly in those still untrammelled areas accessible within a day's drive from Chicago. It begins in January, carries through the rebirth of the countryside in the spring, sees the vibrancy of life in summer, its fulfillment with its hints of later renewal in autumn, and the quiet waiting of winter. This is the sort of writing which can become saccharine and over-personalized, but this the authors have generally avoided; there is a sameness about the writing, however, which tends to blur the distinctness of the seasons and which does not convey the mood, which is so much a part of each passing moment. The reader will find, on the other hand, that the book will sharpen his senses of what goes on in nature, and perhaps this is as much as we can ask of an almanac.

C. P. SWANSON

PLANTS AND ENVIRONMENT. *A Textbook of Plant Autecology. Second Edition.*

By R. F. Daubenmire. John Wiley & Sons, New York; Chapman & Hall, London. $6.95. xii + 422 pp.; ill. 1959.

When compared with the first edition (*Q.R.B.*, 23: 234. 1948), the new edition seems little altered. It has not been expanded, but recent work in plant ecology seems to have been considered, and the 773 items in the list of references include a fair sprinkling from the 1950's. Obvious blemishes in the first edition have been removed. The treatment and point of view are the same.

ECOLOGY OF INLAND WATERS AND ESTUARIES.

By George K. Reid. Reinhold Publishing Corporation, New York; Chapman & Hall, London. $7.50. xvi + 375 pp.; ill. 1961.

The only ecological part of this book is Chapter 13, dealing with Populations in Aquatic Environments (Paul G. Pearson) and Chapter 14, on Aquatic Communities. Most of the book consists of a straightforward treatment of limnology in the classical sense, with some short discussions of estuaries added to justify the title. Estuarine biologists have found that

the book offers little useful to them (Chapter 14, for example, does not discuss a single estuarine community) and will agree with limnologists that Chapter 12, devoted to Animal Inhabitants of Inland Waters and Estuaries, does not contain enough detail to be of value to students, and so far as estuarine fauna is concerned, is so incomplete as to be misleading (*Pensus setiferus* is called "brown shrimp" and *Callinectes sapidus* is not even mentioned). As an introductory limnology textbook, this treatise can serve a useful purpose, and if reworked in the next edition to live up to its title, may become even more useful. Perhaps it is a lost cause (see "Cause," 153 in Roget's *Thesaurus*) to protest that parameter should not be used in the sense of dimension. A number of gaucheries in English usage suggest that this book may have been transcribed from taped lectures. More rigorous editing would have improved the book as reading matter, but such editing is also, perhaps, becoming a lost cause.

JOEL W. HEDGPETH

THE BIRDS OF FINCA "LA SELVA," COSTA RICA: A TROPICAL WET FOREST LOCALITY. *Bull. Am. Museum Nat. Hist., Vol. 121, Art. 2.*

By Paul Slud. American Museum of Natural History, New York. $2.75 (paper). iv + pp. 53–148 + pl. 8–26; text ill. 1960.

A full year of study in a virgin forest on the Caribbean coast of Costa Rica has made it possible for the writer to classify the bird life according to preferred ecological habitats. Within the forest proper, the floor, the understory, the middle forest, and the canopy are considered separately, as well as habitats outside the forest, such as second growth, tree plantations, watercourses, and aerial. A list of the birds characteristic for each and additional pertinent comments is provided. The physical and biotic environments of "La Selva" are described in sufficient detail to give a good picture of the area (there are also a number of plates which vividly emphasize the tropical luxuriousness of the vegetation).

Slud concludes from his detailed observations that the suboscines are an integral, if not dominant, part of the avifauna and that they should not be considered as a relict group that is being replaced by the theoretically, heretofore assumed, more "advanced" oscines. The Neotropical Zone is not considered to be a refuge area but a dynamic evolutionary stronghold, where oscines are no better off than the suboscines. Considerable material is marshalled in behalf of these arguments.

The annotated list of birds is only a small segment of this report; the principal and most important contribution is the detailed ecological discussion.

HENRI C. SEIBERT

VEGETATION UND STANDORTSKLIMA IN EL SALVADOR. *Eine Pflanzengeograpisch-Ökologische Studie. Botanische Studien, Heft 10.*

By William Lötschert. Veb Gustav Fischer Verlag, Jena. DM 14.30 (paper). viii + 88 pp. + 20 pl.; text ill. 1959.

This relatively brief ecological monograph on the vegetation of Salvador treats, following introductory matters, the vegetation of the "tierra caliente," from 0 to 800 meters altitude; the vegetation of the "tierra templada," from 800 to 1800 meters altitude; and the vegetation of the "tierra fria," over 1800 meters in altitude. Bibliography and systematic index are provided. Twenty plates, unfortunately not too well reproduced, depict typical landscapes and plants.

THE BALKAN LAKE OHRID AND ITS LIVING WORLD *Monographiae Biologicae, Vol. IX.*

By Siniša Stanković. Dr. W. Junk, Den Haag. D.G. 35.–. 357 pp.; ill. 1960.

Lake Ohrid, one of the oldest (if not the oldest) lakes in Europe, lies in the southern corner of Jugoslavia with its southwestern border in Albania. It supports important fisheries, notably of endemic salmonids, and a hydrobiological station was established on its shore by the University of Beograd in 1935. This monograph includes much of the work done at that station (quite a bit of it hitherto unpublished), as well as a masterful summary of all available physical and biological information so far published. A glance at the bibliography will show that much of the literature on this lake is scattered in journals not easily accessible in the United States. This monograph, therefore, is the prime source of information about Lake Ohrid and will be an essential reference for limnologists, as well as a fine example of how a monograph of this type should be done. The illustrations are excellent, and the book is indexed by author, organisms, and subject. The English is remarkably clear, although obviously not written by a native of the language. It is a pity that many of our native graduate students cannot write as well.

JOEL W. HEDGPETH

ÉCOLOGIE ET PEUPLEMENT ENTOMOLOGIQUE *des Sables Vifs du Sahara Nord-Occidental. Publications du Centre de Recherche Sahariennes, Sér. Biol. No. 1.*

By Franklin Pierre. Centre National de la Recherche Scientifique, Paris. 32 NF. 332 pp. + 16 pl.; text ill. 1958.

The chapters of this interesting treatise on the "living sands" of the northwestern Sahara and its insect populations run as follows: The living sands of the North-West Sahara; Climatic factors; The endoclimate of the sand; The microclimates of the sand; Edaphic factors; The entomological fauna of

the living sands; Morphological specializations of the sand-dwellers; Physiological specializations of the sand-dwellers; Ethological specializations of the sand-dwellers; The structure of groupings; and The origin of the sand-dweller fauna. An extensive bibliography and a collection of plates showing general aspects of the region are included, but the work unfortunately lacks a subject index. Entomologists and ecologists will find summaries of many useful data and much taxonomy in the treatise; and every biologist concerned with the fauna of arid regions should examine the volume.

SEX RATIOS AND AGE RATIOS IN NORTH AMERICAN DUCKS. *Illinois Nat. Hist. Survey, Vol. 27, Art. 6.*

By Frank C. Bellrose, Thomas G. Scott, Arthur S. Hawkins, and Jessop B. Low. Natural History Survey Division, Urbana. $1.00 (paper). vi + pp. 391–474; ill. 1961.

RECREATIONAL USE OF WILD LANDS.

By C. Frank Brockman. McGraw-Hill Book Company, New York, Toronto, and London. $8.50. xii + 346 pp.; ill. 1959.

There is disappointingly little reference, in this treatise of the recreational use of public wild lands, to any biological aspects. A page and a half is devoted to wildlife conservation in relation to outdoor recreation, and a section of 4 pages is headed "Some Biological Interests of the National Park System." Except for passing reference to game reserves, museums, and government agencies concerned with the living resources of the nation, that is about all. Though the book is written by a professor of forestry, even the chapter on the forests deals more with administration and policy than with the intimate contact with living things and the respite for the human spirit which constitute the greatest recreational value of wooded areas.

CAUSES DE LA RÉPARTITION DES ÊTRES VIVANTS. *Paléogéographie, Biogéographie Dynamique. Evolution des Sciences, No. 10.*

By Raymond Furon. Masson & Cie, Paris. (paper). 168 pp.; ill. 1958.

In this small volume, the well-known paleogeographer R. Furon considers the problems of the geographic distribution of organisms in terms of paleogeography, paleoecology, and paleoclimatology. His emphasis is on biogeography as a dynamic subject. The appearance and disappearance of bridges and barriers, progressive cooling and rewarming of the climates, the great subsidence of the Pacific Ocean, the isolation of Australia and South America, the significance of Wallace's Line, and similar problems occupy his attention. He concludes, sensibly, that the present distributions cannot be fully explained, since they are the result of flights and exterminations, total exodus and partial return, as well as evolution in situ. To the unknown and indecipherable agencies of the past must be added the hand of Man, now transforming the environment and profoundly altering the distributions of animals and plants. The book is thus a sketch of an area of biology still to be developed, rather than an account of completed surveys and well-established conclusions. Written simultaneously with P. J. Darlington's *Zoogeography*, it raises the same questions, although it is of course far from being as comprehensive and thorough a treatment of the subject.

EVOLUTION

A CENTURY OF DARWIN.

Edited by S. A. Barnett. Harvard University Press, Cambridge. $5.75. xvi + 376 pp. + 5 pl.; text ill. 1958.

DARWIN'S BIOLOGICAL WORK. *Some Aspects Reconsidered.*

By P. R. Bell and 5 other contributors. Cambridge University Press, New York and London. $7.50. xiv + 343 pp. + 1 pl.; text ill. 1959.

A Century of Darwin brings together 15 contributors who appraise the current status of major Darwinian concepts or contributions to science in the light of current scientific and philosophical opinion. All except two (Dobzhansky and Romer) are British scientists. The contributions range from appreciative essays and standard reviews to a few of a highly original character that biologists will do well not to overlook. Among these is the controversial essay by Donald Michie, entitled The Third Stage in Genetics, which undertakes to justify Darwin's theory of pangenesis by arbitrarily emphasizing a distinction between the period of classical genetics, when supposedly all heredity was in the chromosomes, and the period of post-war genetic research, in which cytoplasmic inheritance, plasmagenes, transduction, nuclear differentiation, infective inheritance in tomatoes (Glushchenko and Glavinic), and the (unconfirmed) effects of duck DNA injections gloriously point the way to the "third period." It might surpise Michie to learn that Darwin's pangenesis was after all not the first postulation of self-replicating particles (vide Maupertuis). Nor is this "heroic attempt to unite the heredity of the germ-line and the development of the body in a single scheme, in which the germ-line is not set apart, remote and inviolable, but is subject to the forces of development and decay which govern the rest of the body," as Michie describes pangenesis in terms which might be taken to

apply to his own essay, very convincing. The chromosome theory of heredity is not rightly to be designated as a "dualistic" theory—one might as well say that anyone who recognizes the existence of both DNA and RNA is a dualist in theory. The central problem of genetics remains that of understanding the ways in which the hereditary materials influence the cell and the organism, as well as the extent to which the genetic material is in turn dependent upon the rest of the living system. No clear-headed geneticist has ever forgotten that traffic is two-way. At the very least, the synthesis of new genes and chromosomes depends upon the supply of substrates from the cytoplasm and, ultimately, the outer world. The question of whether changes in the genetic material of somatic cells can bring about corresponding changes in the genetic material of reproductive cells is a special case, with the burden of proof on the claimant.

Many of the reviews in this volume are fine summaries of their subjects. A few excel in originality. Among these the discussion of Natural Selection and Biological Progress, by J. M. Thoday, must be singled out for the truly exceptional way in which it illuminates its subject. The importance of maintaining both genetical stability and genetical versatility, and the nature of the mechanisms that do this, are brilliantly set forth. Darwinism and Ethics (D. Daiches Raphael) is likewise an interesting attempt to clarify the perennial issues raised by Thomas Henry Huxley and by Darwin himself. These two essays alone make purchase of the book by the biologist virtually essential.

The remaining contents, many of which deserve a fuller comment, are as follows: Theories of Evolution (C. H. Waddington); Species after Darwin (Th. Dobzhansky); Darwin and Animal Breeding (John Hammond); Darwin and Classification (R. A. Crowson); Darwin and the Fossil Record (A. S. Romer); Darwin and Embryology (Gavin de Beer); The Study of Man's Descent (W. Le Gros Clark); The "Expression of the Emotions" (S. A. Barnett); Sexual Selection (J. Maynard Smith); Darwin and Coral Reefs (C. M. Yonge); Darwin as a Botanist (J. Heslop-Harrison); Darwinism and the Social Sciences (D. G. MacRae). It is evident from this list of subjects and authors that the full range of Darwin's contributions has been considered in the light of present biology, and that the galaxy of authorities could hardly have been better chosen. The result is a volume that is among the finest to have emerged from the plethora of writing during the period of the Darwin centennial.

Darwin's Biological Work: Some Aspects Reconsidered is another of the Darwin centennial volumes. Like the preceding work, it is a reappraisal of various aspects of Darwin's contributions to biology; but unlike *The Century of Darwin*, it is made up of fewer and lengthier essays. In some cases these penetrate so deeply into the more recent studies carried out on subjects cognate to those which Darwin explored that the relationship to Darwin's studies and the perspective sought are obliterated in the details of a review of current developments. This, I believe, is particularly true of P. R. Bell's contribution, The Movement of Plants in Response to Light, which becomes a very exhaustive review of the nature and actions of auxin before it is done. Considered solely as a review of the latter subject, it is very fine. J. Challinor reviews the subject of Palaeontology and Evolution in a similar detailed fashion. J. B. S. Haldane contributes a lengthy discussion of Natural Selection which, perhaps because the subject is so central to Darwinism, or perhaps because of his own special gifts of lucidity and balance, is to me the most valuable part of the volume. Developments in the Study of Animal Communication are interestingly discussed by Peter Marler. H. L. K. Whitehouse clarifies the problems and current status of knowledge in regard to Cross- and Self-Fertilization in Plants, a subject which was of the most intense interest to Darwin. Finally, the volume is completed by a very perceptive and valuable essay in the history of evolutionary ideas. It is entitled Buffon, Lamarck and Darwin: the Originality of Darwin's Theory of Evolution, and is written by J. S. Wilkie. Although I differ with the author in regard to his evaluation of the mutual influence of Buffon and Maupertuis on each other, and while I am surprised at the neglect by the author of A. O. Lovejoy's very full treatment of Buffon's evolutionary ideas, the essay nevertheless deserves high praise for its scholarly balance and insight.

Together, these two volumes would seem to have said all that could be, or need be, said in praise and re-evaluation of Darwin's revolutionary contributions to biology. The period of the centennial has, however, produced many more such books. These two were among the first to appear. They set a very high standard for those published subsequently to match. It is quite remarkable that in these two collections there is almost no overlapping or duplication of topics. Even where the subject treated would seem to be essentially the same, as in the case of the essays on the fossil record by Romer and by Challinor, or in the treatment of natural selection by Haldane and by Thoday, there is really sufficient difference in point of view and choice of material to make both contributions well worth while. Romer thinks in terms of vertebrates, Challinor of invertebrates; Haldane's essay is comprehensive, Thoday's is directed to special aspects of selection in relation to biological progress. That in the later additions to the Darwinian centennial literature duplication could be so happily avoided is too much to hope for.

BENTLEY GLASS

IMPLICATIONS OF EVOLUTION.

By G. A. Kerkut. Pergamon Press, Oxford, London, New York, and Paris. $5.50. x + 174 pp.; ill. 1960.

It is the opinion of G. A. Kerkut that the time has come to look at accumulated facts to reassess their relationship to that fundament of biological theory that says all living forms have evolved in orderly sequence *"from a unique source"* (italics his). Since I agree with him, and had been hoping for an expert source to provide detailed support for my general arguments for a critical reexamination of the concept of the unity of life, I welcomed the *Implications of Evolution* and read it eagerly. I greatly enjoyed it.

The author's qualifications are excellent. He is the reviser of Borradaile, Eastham, Potts, and Saunders' *Invertebrata*, and is now in the Department of Physiology and Biochemistry, of the University of Southampton. He takes upon himself the task of challenging assumptions about evolution held to be basic by many. But he is not alone, and the scepticism of many others (e.g., Pantin, Boyden, Whittaker, Berg) lends timeliness to his book and force to his arguments.

Kerkut's approach is exemplary. The Introduction includes a tutorial dialogue in which the dogmas and attitudes laboriously assumed by a student are brought into question. One feels with the vexed student a certain discomfort, but no immediate need to abandon a position which one feels sure is in the vanguard of science. One goes to the main text asking, "What next?"

The text provides a systematic discussion of taxonomic origins and relationships. First comes the problem of the origin of life: unique or multiple? To begin to resolve this question requires that a choice be made: which is greater, the similarities or the differences between groups of organisms? Following that discussion, viruses, rickettsiae, and bacteria are briefly examined. Kerkut concludes that there is no certainty of relationship between or among them. In discussing viruses, Kerkut introduces his use of the "grade of organisation." "A *grade*," he says, "may be regarded as a group of individuals that are united by certain common properties but are not derived from a common close ancestor. The grade indicates the level of organisation rather than a close phylogenetic relationship" (p. 21). We cannot quarrel with this, but it might have been useful to have had a mention of the Huxleian clade with which the grade can best be compared.

Successive chapters deal with the Protozoa, the origin of the Metazoa, the relationships among invertebrate metazoans, the nature of certain biochemical evidences of evolution, and the evolution of the vertebrates. Comparisons are often listed for easy reference and orderly discussion.

Considerable interest resides in Chapter 8, which considers biochemical studies of phylogeny. The greater part of Chapter 8 has to do with phosphagens. It would appear that recent work, particularly from France, tends to overweigh the Needham-Baldwin conclusions about the distribution of adenine and creatine phosphates. Creatine phosphate is much more abundant than previously supposed, and other guanidines are continually being uncovered in more and more groups of animals. Particular phosphagens are not necessarily universally distributed throughout any phylum in which they are recorded.

Less relevance to the general theme is apparent in Kerkut's chapter dealing with vertebrate paleontology and evolution. Why this should be so is not easy to determine. Perhaps it is because intraphylum relationships here are clearer than the interphylum relationships of the animal "kingdom" as a whole, and clearer even than intraphylum relationships in many invertebrate groups. Nothing Kerkut says in this chapter is to me as forceful as things said by him elsewhere in the book. It is to be kept in mind that most of the principles of animal evolution have come from vertebrate studies, to be imposed upon invertebrate studies. Possibly, among vertebrate specialists the variations and implications of phylogenesis within the phylum have been more widely discussed, so that ideas of multiple origins of different groups come as no surprise.

Kerkut concludes: biogenesis from non-living matter may or may not have occurred; biogenesis may have occurred more than once; most phyla of organisms may not be related at all, similarities evidencing convergence rather than phylogenetic commonality. All these points deserve our most serious attention. There must be constant reconsideration of the evidence so that our theories fit it, and not it our theories.

The book suffers occasionally from typographic lapses. Page 132 is particularly unfortunate, with three proper nouns misspelled. One word which draws bothered attention, although it is not an error, is "homoiology." It is defined as being: "the independent derivation of similar structures in separate lines that are phylogenetically related" (p. 108). Kerkut has elaborated this for me (in litt.) as follows: "It indicates that the basic genes, for a structure to evolve are present; it merely requires the correct environmental selection. The structures are not strictly homologous, since they have been independently developed from an ancestor that did not possess that structure. They are not analogous since they come from identical embryonic material and are usually under similar genetic control." The term homoiology was introduced by Ludwig Plate in 1901 and elaborated in 1922 in his *Allgemeine Zoologie und Abstammungslehre* (p. 7). It seems not to have got wide acceptance, but Marcus (*Q.R.B.*, 33: 43.

1958) reintroduced it and Kerkut follows this usage. The word apparently roots in the Greek *homoios*, like or similar, according to Partridge akin to and probably derived from the Greek *homos*, the same, common, or like. Homoiology, as defined by Kerkut and his predecessors, is remarkably similar to the parallel variation by homologous mutation described by Huxley (*Evolution: The Modern Synthesis*, p. 510) and the "parallel trends" of Simpson (*The Major Features of Evolution*, p. 246). Both of these explicit terms are commonly referred to as "parallelism." This term might very well be retained as the operative term in preference to "homoiology" because of its more general usage and because "homoiology" suffers from its kinship to homology. Being rather difficult to pronounce, and given our rather unfortunate tendency to abandon vowel digraphs, it is to be expected that homoiology would soon subside through homeology into homology (cf. homothermy), leaving us with only parallelism as a clearly distinguishable term, anyway. Perhaps Novikoff would call the result homomorphy, and this might be hoped to lead to a more suitable term until one remembers homeomorphy, as defined by Haas and Simpson (*Proc. Amer. Phil. Soc.*, 90: 339. 1946). Nonetheless, there is a concept here that needs attention and care in definition whenever we use it, no matter what we call it.

One can quarrel with the conclusions of this book, and it is to be expected that many will. It will have succeeded in its task if it arouses the interest of some to quarrel and if it brings back to light many assumptions tidily packaged and put away as being no longer open to question.

J. R. NURSALL

ADAPTATION. *Foundations of Modern Biology Series.*

By Bruce Wallace and Adrian M. Srb. Prentice-Hall, Englewood Cliffs. $1.50 (paper). xiv + 113 pp.; ill. 1961.

The "raison d'etre" for the short (some 12-dozen pages each), 6 × 9 inch, paperbound Prentice-Hall Foundations of Modern Biology Series is to permit the use of a variety of different and inexpensive books in any one course so that "teacher prerogatives can best be met." One sees nothing wrong with giving the widest feasible latitude to "teacher prerogatives" so that "each teacher of biology [can] determine the level and structure of his own course," especially if the course is an advanced one.

Adaptation is well worth its cost! Let us examine just one of its 11 chapters (each with a brief "In General" paragraph or two at the end), the one on Modifications of Reproductive Behavior. It begins with a statement on like begetting like and like mating with like, notes the presence of small bristles at a number of places on the body of the common fruit fly, carefully discusses experimental evidence indicating that "some relation exists between numbers of bristles possessed by parental flies and those of their offspring," and then proceeds to species-hybrids and the species-definition as exemplified by dipteran sibling species, anuran mating timetables, the inheritance of flowering time, and "a whole [fascinating] battery of isolating mechanisms." This is surely a good book.

LEE EHRMAN

GETREIDEUMWANDLUNG UND ARTPROBLEM. *Eine Historische Orientierung.*

By Mauritz Dittrich. Veb Gustav Fischer Verlag, Jena. DM 20.15. xii + 218 pp.; ill. 1959.

It is necessary to read the sub-title and the address of the author (Merseburg/Saale) to understand the scope and intent of this book. Dittrich lives in East Germany, where his scientific investigations may be free, but where he is constantly confronted with Soviet Biology and Lysenkoism. It is therefore not surprising that he chose the subject of transmutation (the sudden transformation of one known species into another one) about which there has been much controversy, and which, at least for those in daily contact with the Russians, is not yet dead.

Cleverly and thoroughly, he uses 110 pages of the book for showing how the idea of transmutation has been recurring from the times of ancient Greece, through the Middle Ages, until the present day. Implied is the criticism of the Lysenko school that they really have nothing new to shout about. To the geneticist who is not historically minded, the argument that divine creation precludes transmutation is surprising: he knew only that it had been used against evolution. The work of the Lysenkoists is dealt with in some 40 pages, and although Dittrich discusses the *experiments* seriously, he points out that none of the claims has been proven beyond doubt. The illustrations, taken from the original Russian research papers, are well reproduced and, with their German legends, are a useful item of reference.

An appendix of 15 pages tabulates everything from the terminology and arguments for and against transmutation to the localities from which these strange occurrences have been reported. The well-organized reference list includes some 600 titles and such authors as Goethe, Engels, Michurin, Oparin, and Schiemann. Although Goldschmidt's macro-mutations are mentioned, his name is excluded from the list of references along with all other American geneticists. There is a complete author and subject index.

It seems unlikely that Dittrich will find many American readers, and those who do read this book may wish he had put his condemnation of Lysenko-

ism into direct words rather than into subtle wording of objective statements. A Lysenkoist, after reading this book, might well wish his own publications had been anonymous, like those of many 19th century writers on this subject, for he can hardly fail to realize his shaky position. It is perhaps for this purpose that the book was written: to widen the horizon of the biology student in East Germany today.

L. M. STEINITZ-SEARS

VERTEBRATE SPECIATION. *A University of Texas Symposium.*

Edited by W. Frank Blair. University of Texas Press, Austin. $8.50. vxi + 642 pp. + 16 pl.; text ill. 1961.

This symposium records a conference held in October, 1958, as part of the celebration of the seventy-fifth anniversary of the University of Texas and, incidentally, the hundredth anniversay of the Darwin and Wallace announcements of natural selection. Twenty-one papers were read and are now published without essential change, along with brief introductory remarks by five moderators and a tape-recorded discussion. Among authors, co-authors, moderators, and discussants there are 50 contributors to the volume, and the naming of only a handful of them in this review has no evaluative implications.

"Speciation" is interpreted broadly to include diverse evolutionary phenomena within species and among related species, and not only the splitting of specific lineages, although there is some emphasis on the latter. The session topics were as follows: Isolating mechanisms (4 papers); Evolution of behavior (4 papers); Polymorphism (2 papers); Polytypic species (2 papers); Population dynamics (4 papers); and Age and origin of species (5 papers). Most of the authors are American vertebrate zoologists, but one is an American Pleistocene stratigrapher and three are from abroad: Svärdson (Sweden), Littlejohn (Australia), and Kosswig (Germany), all of whom, as well as the stratigrapher, contributed to the session on the age and origin of species. Although moderated by a paleontologist, that session had minimal paleontological content and the others had almost none.

Most of the papers are reports on specific research projects, varying from 5 pages by Moore on nuclear transplantation experiments with two species of frogs to 70 pages (including plates) by Haskins and others on a long and elaborate study of polymorphism in one species of fish (*Lebistes reticulatus*). A few of the papers are more general in nature, for example, a review of the evolution of visual communication by Marler, and one of structure and behavior in reptiles by Evans. The inclusion of several papers on behavior is unusual and valuable in a symposium of this kind.

No attempt was made to review a whole session topic or to summarize or integrate a theoretical aspect of speciation. The result, as in most symposia, is a mosaic of isolated contributions, but all of those contributions are competent and many are important. In conjunction, they afford an excellent sampling of the kinds of work current in this field. Everyone interested in the subject will want to read them.

The book is amply illustrated, including 16 color plates (in the Haskins contribution), a folded map, and many line cuts and half-tones. The reproduction of the illustrations is uneven in quality, but in general the volume is well manufactured. The editing is good. In consideration of its size, complexity, and technical nature, the book is surprisingly inexpensive, as books go nowadays.

G. G. SIMPSON

FLORA OF THE LOWER HEADON BEDS OF HAMPSHIRE AND THE ISLE OF WIGHT. *Brit. Museum Geol., Vol. 5, No. 5.*

By M. E. J. Chandler. The British Museum (Natural History), London. 30s. (paper). ii + pp. 93–157 + pl. 25–30; text ill. 1961.

FORAMINIFERA FROM THE SACATE FORMATION SOUTH OF REFUGIO PASS, SANTA BARBARA COUNTY, CALIFORNIA. *Univ. Calif. Publ. Geol. Sci., Vol. 37, No. 3.*

By Gordon R. Hornaday. University of California Press, Berkeley and Los Angeles. $2.00 (paper). iv + pp. 165–232 + 13 pl.; text ill. 1961.

TWO JURASSIC TURTLE SKULLS: A MORPHOLOGICAL STUDY. *Bull. Museum Comp. Zool., Vol. 125, No. 3.*

By Thomas S. Parsons and Ernest E. Williams. Museum of Comparative Zoology, Cambridge. $1.65 (paper). ii + pp. 43–107 + 6 pl.; text ill. 1961.

GENETICS AND CYTOLOGY

THE SCIENCE OF GENETICS.

By Charlotte Auerbach; drawings by Inge G. Auerbach Linker. Harper & Brothers, New York. $5.95. xii + 273 pp. + 8 pl.; text ill. 1961.

Charlotte Auerbach, an authority in the field of chemical mutagenesis, was the first to establish the mutagenic capacities of mustard gas, just as H. J. Muller was the first to establish the mutagenic properties of X-rays. This, as far as the reviewer is aware, is her second attempt at the difficult but necessary task of the popularization of science. It is a very

good one and a logical follow-up to her modest first endeavor (*Genetics in the Atomic Age*, 1956).

In that first book Charlotte Auerbach discussed "one particular branch of genetics: mutation and its connection with radiation and nuclear fission." This time she has extended the scope of her writing to include, in addition, A Very Little Statistics (chapter 6); Genetics Counseling (chapter 12); The Game of Life: Mendel's Second Law (chapter 19); Johannsen's Beans (chapter 21); A Success Story: Hybrid Corn (chapter 22); and Evolution as Seen by the Geneticist (chapter 29). This last chapter, and certainly its conclusion, is especially stimulating. And isn't stimulation precisely what is desirable in a scientific composition styled for general readership? Couple a core of sound scientific facts with an enthusiasm that is decidedly contagious, and what more could be asked for? Consider the prefactory announcement: "... it is my firm conviction that a clear grasp of the elements of genetics is indispensable to anybody who wants to take away from such educational occasions more than a few awe-inspiring technical terms, a few three-letter words like DNA and RNA, and a hazy conviction that modern geneticists are doing wonderful things. It is my intention to provide the indispensable knowledge without which the most recent advances in genetics cannot be understood."

Once again I. G. Auerbach (Linker) has provided her sister with a set of simple and appealing sketches to complement the text. They should aid the many non-biologists, blossoming biologists (high school variety), and biologists themselves who, one hopes, will read this book and be lured to approach the Reading List offered at the very end of it.

LEE EHRMAN

MÉCANISMES D'AUTOREPRODUCTION. *Mécanismes Généraux, Constituants du Cytoplasme, Hérédité Contagieuse, et Cytoplasmique, Anticorps, Acides Nucléiques des Virus, Virus des Végétaux, Transferts Génétiques, Virus des Animaux et Relations avec les Cellules.*

Edited by J. André Thomas. Masson & Cie., Paris. (paper). xviii + 428 pp.; ill. 1957.

This volume, third to appear in the series to which it belongs, contains 9 review articles by well-known French and Belgian workers in the field of "autoreproduction," that is, the study of the self-duplicating properties of cellular components and viruses. The introductory review, by Jean Brachet, concerns the autoreproduction of the principal constituents of the animal cell. It is supplemented by an article written by M. de Deken-Grenson, dealing specifically with these properties of cytoplasmic constituents, and their relationship to genetic continuity. Philippe L'Heritier entitles his review "Contagious heredity and cytoplasmic heredity." It describes many phenomena of critical significance in the evaluation of these problems. A short contribution on the formation of antibodies (P. Grabar) is followed by a lengthy one on the organization of the nucleic acids and autoreproduction in viruses (E. Barbu). In this field advances have been so rapid that even the best of reviews is quickly out of date. Autoreproduction in certain plant viruses and in certain animal viruses is discussed by P. Limasset in the case of the former, and independently by Geneviève Cateigne and C. Hannoun in the case of the latter. Cateigne takes up in particular the physiological balance between virus and cellular host, while Hannoun considers the relationship to the host's metabolism proper. The remaining review (René Thomas) deals with genetic transfer of information to the macromolecular scale, and considers phenomena such as lytic infection, transduction, lysogeny, and transformation in terms of the state of the foreign genetic material following its entrance into the host cell, and especially its localization, its evolution, and other properties.

SEXUALITY AND THE GENETICS OF BACTERIA.

By François Jacob and Elie L. Wollman. Academic Press, New York and London. $10.00. xvi + 374 pp.; ill. 1961.

To the interested microbiologists and geneticists for whom bacterial genetics gradually has become a bewildering maze, this straightforward and informative description merits close attention. There is no attempt to cover all areas of bacterial variation. For example, population genetics and transformations are scarcely mentioned. *Escherichia coli* and its bacteriophages provide the experimental systems. The content of the book reflects its evolution and the specific areas in which its authors and their associates have so heavily contributed. The treatment directly originated in the thesis of E. L. Wollman (*Recherches sur la conjugaison des bactéries et sur le déterminisme génétique de la lysogénie*, University of Paris, March 18, 1958). An expansion of the thesis appeared in a French version, by E. L. Wollman and F. Jacob (*Q. R. B.*, 35: 170. 1960). The current volume, while largely a translation of the French publication, also contains extensive additions, particularly in the later chapters.

The central themes of the book are the genetic determination of lysogeny and the process of bacterial conjugation. These two, initially diverse, topics converge as the volume develops. Their union is summarized in a description of the episome concept at the end of the book. A further topic of major interest is gradually developed from genetic analyses utilizing conjugation, as well as from considerations of the phenotypic expression of the genetic material.

This topic, which has received the most extensive attention since the French edition, involves the astute development of new ideas concerning the organization of genetic material as related to genic activities. The book represents a landmark along the road of our understanding of gene action. For, while the clever genetic analyses of these workers have led to the brilliantly conceived concepts they discuss, it is probable that their further elucidation will rely more heavily on biochemical studies of cell-free systems. The description by Jacob and Wollman indicates that genetic experimentation will be a potent and versatile companion in these endeavors.

PHILIP E. HARTMAN

DEVELOPMENTAL GENETICS AND LETHAL FACTORS. *By Ernst Hadorn; translated by Ursula Mittwoch. John Wiley & Sons, New York; Methuen & Co., London.* $8.50. xviii + 355 pp.; ill. 1961.

It is indeed unfortunate that, because of the language barrier, many excellent books written in German virtually do not exist for many American scientists, graduate students, and undergraduates. Some Americans, although they do read German, do not feel that they can afford to spend the extra time needed to read German books. This inability or lack of time to read German can put one in a particularly undesirable position when one cannot or will not read important texts that have no counterparts in English such as, for example, Alfred Kühn's *Vorlesungen über Entwicklungsphysiologie* (Springer-Verlag, Berlin, 1955) (*Q. R. B.*, 31: 31. 1955) and Otto Pflugfelder's *Entwicklungsphysiologie der Insekten* (Akademische Verlagsgesellschaft, Geest and Portig K.-G., Leipzig, 1958), to mention only two. Therefore it is indeed fortunate that Ernst Hadorn's *Letalfaktoren* (Georg Thieme Verlag, Stuttgart, 1955) (*Q.R.B.*, 31: 218. 1956), which formerly belonged in the above category, now has a very good counterpart in English by virtue of Ursula Mittwoch's excellent translation of this book.

When the original German edition appeared in 1955, it received excellent reviews, and although there has been a hiatus of six years between the publication of the German and English editions, there is no reason to change one's mind about the value of the book. It contains not only a thorough examination of the significance of lethal mutations in both genetics and development, but also clearly discusses and defines most of the fundamental concepts of developmental genetics: penetrance, expressivity, pleiotropy, phenocopies, phase specificity, cell and organ specificity, cell autonomy, etc. At the present time it is the only book available that could be used as a textbook in a course in developmental genetics.

As Hadorn indicates in his Preface to the English edition, this is, for the most part, a direct translation of the German edition and not a new edition. He has, however, added over a hundred new references, most of these from the years 1955 and 1956 along with some from 1954 and 1957 and a few from 1952, 1953, 1958, and 1959. The way in which information from these new references has been added to the text is not immediately obvious without a direct comparison of the German and English editions. In most cases he has adroitly added statements at the ends of paragraphs or sections in the appropriate places in the text. It is to be hoped that soon Hadorn will not be satisfied with this useful device of bringing a book up to date, and that he will produce a completely new, revised edition of his book which will appear simultaneously in German and in English, the latter for those who would like to use it as a textbook in their classes, if not for those who cannot or will not read German.

THEODORE R. F. WRIGHT

GENES, ENZYMES, AND INHERITED DISEASES. *By H. Eldon Sutton. Holt, Rinehart and Winston, New York.* $3.50. viii + 120 pp.; ill. 1961.

Books in biology may be classified into main categories: the exhaustive treatise, taxing but invaluable; the small, compact, specialized monograph, thorough but of limited appeal; and a third group, perhaps the most difficult to pull off successfully, the slim volume, typified by this book, that knits scattered knowledge together and brings cohesion and understanding to the necessary fragmentation of biological research.

Sutton paints boldly with easy strokes and covers the subject in a scant hundred pages. His point of departure is the classic paper of Avery, MacLeod, and McCarty of 1944 in which evidence was first presented that DNA is the genetic material. The modern concepts of fine structure genetics are ably discussed and are properly prefaced by an abbreviated account of DNA and RNA chemistry. This section was so readable that it was regrettable from the sake of completeness that the exciting discoveries of Nirenberg and Matthaei were unknown at the time the book was written. The fact that we now know that polyuridylic acid codes for L-phenylalanine and polycytidylic acid for L-proline indicates that the solution of some of the problems of coding may not be so distant. A discussion of protein structure and its genetic control is illustrated by a consideration of the abnormal hemoglobins, but more discussion could have been given advantageously to genetic control of protein structure in other organisms. The various steps of protein synthesis are considered; unfortunately, however, Monod's recent concepts of structural and regulatory mutations are too recent to be included. Inborn errors of metabolism are il-

lustrated by appropriate diseases, and specific examples of genetic variation in human populations unassociated with overt disease are included. Recent experiences revealing the genetic diversity of human populations by unusual sensitivity to drugs such as primaquine, succinyl choline, and isoniazid are also mentioned. The book closes with an optimistic chapter on treatment of inborn errors in which the important distinction between cure of a disease and control is emphasized.

The book is particularly noteworthy for its clear and pleasant style. The line diagrams, some taken from the literature but many original, are excellent. When a book is as good as this, there can be little harm in offering some mild criticism. To publish such a book in a hard cover today, when paperbacks can no longer be deemed controversial, seems downright extravagant. Retrenchment of the publishers' superfluities would permit this excellent little book to be appreciated by a wider audience.

ALEXANDER G. BEARN

GENERAL AND SYSTEMATIC BOTANY

ARIZONA FLORA.

By Thomas H. Kearney, Robert H. Peebles, and collaborators; second edition and supplement by John Thomas Howell, Elizabeth McClintock, and collaborators. University of California Press, Berkeley and Los Angeles. $12.50. 1085 pp.; ill. 1961.

This excellent flora was first published in 1951 (*Q. R. B.*, 28: 64. 1954) and since then has served as the standard reference to the vascular plants of Arizona. The senior author, Kearney, remained a keen student of the flora of Arizona and continued revision of this work until his death. The changes he left in manuscript and other pertinent alterations contributed by his associates and collaborators are included in the present volume as a fifty-page supplement to the earlier work, which adds greatly to the value of it. As a field manual, this volume, which now records 3,438 species that grow spontaneously in Arizona, is rather large and heavy, but it is reasonably sturdy and well bound. The chief inconvenience, however, is in determining whether a change or addition has been made in the supplement. The index to the supplement is of some help, but the most efficient way to solve this problem is to spend an hour or so making marginal notations at appropriate places referring to the pertinent pages in the supplement. With a conveniently annotated copy, anyone interested in the plants of Arizona can be grateful for this updated reissue of a classic work.

H. LEWIS

ILLUSTRATED FLORA OF THE PACIFIC STATES. *Washington, Oregon, and California. Bignoniaceae to Compositae. Volume IV.*

By Roxanna Stinchfield Ferris. Stanford University Press, Stanford. $17.50. viii + 732 pp.; ill. 1960.

Publication of this volume marks the completion of an ambitious work initiated by Leroy Abrams and now brought to a fruitful conclusion by the dedicated and extremely competent labors of Roxanna Ferris. The present volume includes 1,124 species, over 900 of which are Compositae. As in preceding volumes, every species is illustrated with a line drawing which greatly facilitates identification. This volume also includes a key to all of the families represented in the 4 volumes. Like those in the rest of the volume, this key is carefully prepared and is remarkably workable, considering the great number of variables that must be taken into account. In addition, there is an index to common names and an idex to scientific names, both of which cover all 4 volumes.

H. LEWIS

INTRODUCTION TO PLANT GEOGRAPHY *and Some Related Sciences.*

By Nicholas Polunin. McGraw-Hill Book Company, New York, Toronto, and London. $10.00. xx + 640 pp. + 1 folded map; ill. 1960.

During most of the twentieth century, plant geography has been rather definitely divided into floristic plant geography and physiological plant geography or plant ecology. The former has roots directly traceable to the eighteenth century, when botanical exploration and the development of plant taxonomy proceeded hand in hand. The latter hardly existed before Darwin, whose concept of adaptation led logically to the study of structural and functional adjustment of plants to their environments. Traditionally, floristic plant geography attempts to explain the present distribution of taxonomic units in terms of past migrations and evolutionary processes, and physiological plant geography attempts to explain present distribution of plant communities or vegetation in terms of physiological response to environmental factors. This contrast, which I have somewhat oversimplified, is reflected in the fact that textbooks of plant geography almost never attempt to cover the entire field. Polunin has attempted a reconnaissance of the whole spectrum—descriptive and interpretive, static and dynamic, taxonomic entity (taxon) and vegetational unit (econ), present and past, wild and cultivated, and land (polar, temperate, and tropical) and water (fresh and saline).

This encyclopedic text also includes, in separate chapters, discussion of the materials from which hypotheses concerning plant distribution are con-

structed: physiological reactions and structural adaptations, dispersal and migration, genetics and evolution, factors of the environment, historical geology, and the self-induced changes in vegetation that presumably occur in a stable environment (succession and climax). Nevertheless, the European system of vegetation analysis that has come to be called plant sociology is merely mentioned in passing, and the discussion of vegetation is presented in terms of the Anglo-American dynamic systems made famous by Cowles, Clements, and Tansley.

The author's decision to cite only books, most of which appear as recommended supplementary reading lists at the ends of chapters, is a disappointment. The text is sprinkled with the names of outstanding workers, but the citations are limited to "in litt." or "voce." The highly readable text thus has some of the flavor of a lengthy and personal essay on plant geography, rather than a reference book for the serious student. The intimate flavor is further enhanced by many personal anecdotes, such as the author's discovery of Prince Charles Island prior to its official discovery by the Royal Canadian Air Force (p. 127). Furthermore, this restriction on citations required the omission of many valuable works on vegetation. For example, many important contributions to our understanding of the vegetation of polar regions had to be omitted because the author states that the only book on polar vegetation is that of Polunin.

The reader will be grateful to the author for his policy of defining the rather awesome terminology of plant ecology at the point of its first use in the book. This book should serve admirably as an introduction to the variety of approaches, disciplines, and problems that constitute the synthetic field of plant geography.

JOHN C. GOODLETT

QUELQUES RÉSULTATS DE PALYNOLOGIE ANALYTIQUE ET DESCRIPTIVE POUR LE MAROC. *Trav. inst. sci. chérif., sér. botan. No. 23.*

By Gisèle Panelatti. Institut Scientifique Chérifien, Rabat. 4.80 NF (paper). 80 pp.; ill. 1961.

A REVISION OF THE GENUS *Anisotome* (UMBELLIFERAE). *Univ. Calif. Publ. Botany, Vol. 33, No. 1.*

By John W. Dawson. University of California Press, Berkeley and Los Angeles. $2.00 (paper). iv + 61 pp. + 17 pl.; text ill. 1961.

PLANT MORPHOLOGY AND DEVELOPMENT

RECHERCHES SUR L'ANATOMIE DES ASPHODELES DU MAROC. *Trav. inst. sci. chérif., sér botan., No. 24.*

By R. Lardier. Institut Scientifique Chérifien, Rabat. 5.60 NF (paper). 52 pp.; ill. 1961.

PLANT PHYSIOLOGY

PLANT PHYSIOLOGY. *A Treatise. Volume I A: Cellular Organization and Respiration.*

Edited by F. C. Steward. Academic Press, New York and London. $13.00. xxviii + 331 pp.; ill. 1960.

The intent of this 6-volume series is to present the full scope of contemporary plant physiology with sufficient detail to be considered an advanced treatise. In a work of this sort the outstanding problem is one of selection. Experimental procedures must be described as well as basic concepts if the writing is to be more than superficial, yet obviously there is room for only a minute fraction of the possible material (compare, for instance, the 18-volume *Handbuch der Pflanzenphysiologie*, each volume of which is equal in size to about 2 of the present series).

Of the 3 chapters in this volume, the one on Proteins, Enzymes, and the Mechanism of Enzyme Action (B. Vennesland) is outstandingly successful. The concepts are presented with striking clarity; the choice of illustrative examples is perfect; and a very real feeling is conveyed of the excitement of a field expanding with very great speed and enthusiasm. The material even includes a lucid presentation of some of the more basic kinetic considerations (Michaelis-Menten and Arrhenius equations, for example). Writing with a clear and incisive style, Vennesland has been able to effect a model condensation of a very large field.

Cellular Respiration (D. R. Goddard and W. D. Bonner) is a successful outline of another part of plant biochemistry. Here, however, the conflict between adequate presentation of any given topic in depth, and inclusion of all the necessary topics, is more apparent. All of the relevant concepts are certainly included, with the possible exception of the function of lipoidal components of mitochondria in electron transport. However, there is an occasional breathlessness in the presentation of supporting details. A number of these may have been trimmed to the point where understanding will not be easy for students approaching them for the first time. Two minor errors include listing the oxidized form of FMN as the "leucoflavin," and calling GDP a "pyrimidine diphosphate."

The article, The Plant Cell and its Inclusions (R. Brown), would seem to be intended to provide the cytological background for understanding physiological functions of plant cells. This aim is realized in one very interesting section (pp. 60–80), which discusses the structure and physical chemistry of cell mesoplasm and membrane surfaces. It includes a commendable and thoughtful attempt at correlating phenomena such as protoplasmic streaming and cytoplasmic viscosity, with the electron microscope ob-

servations of the endoplasmic reticulum, and with the basic facts of protein chemistry and structure.

Less useful are the portions of Brown's article devoted to a description of the chemical structures of major cytoplasmic components (pp. 47–60). This material would usually be a part of any biochemistry course, and it seems out of place to repeat it here. Another large section (pp. 1–19) simply repeats a portion of basic plant anatomy and histology at a fairly superficial level. Students advanced enough to be reading the present treatise would certainly have come across this material in general botany or general biology previously. Much worse is the attenuated description of the overall metabolic systems of the cell, and their distribution (last 25 pages). The material has been so grossly over-simplified here that it is almost misleading. If a student has a general idea of biochemistry, this part will appear ridiculous; if he does not know any biochemistry, he will not learn anything at all from this treatment.

Other parts of the manuscript, potentially of considerable interest, are marred by errors or omissions. At one point (p. 21), in a section discussing the dimensions of the cellular systems, a series of elaborate calculations led the author to the conclusion that in root cells "...the fresh weight is approximately 100 times greater than the dry weight." It would seem that devotion to the calculations without sufficient care in the basic assumptions has led to the false conclusion that roots have only about 1% dry weight. On p. 22 there is another series of involved calculations related to the numbers of protein molecules in a cell and its various layers. These calculations are based on an assumed "average" molecular weight for plant proteins of 10^6, whereas it is much easier to find proteins with molecular weights on the order of 10^5 or below.

Especially disappointing are the deficiencies relating to the structure and function of cell parts. In several places, for instance, a definite chemical structure (protein-phospholipid-protein sandwich) is assigned to the double membranes seen so frequently in electron microscope pictures. The double membranes of chloroplasts are stated to have the same chemical structure. It is known by now that chloroplasts contain little or no phospholipids, but rather have galactolipids and sulfogalactolipids in large amounts. Thus the assignment of a specific structure by Brown represents a speculation on the basis of inadequate knowledge, and was not clearly labelled as a speculation.

The discussion of microsomes fails to mention the rather common conclusion that the isolated structures probably represent rolled up pieces of endoplasmic reticulum membranes. The discussion of proplastids is in no way illuminating, and omits entirely the very germane and fascinating literature on their stepwise development into mature green chloroplasts, with all the physiological implications of this process. The discussion of flavones and anthocyanins (or indeed, of almost any other component) does not include any mention of the specificity of cell types in which they are found, with the consequent implications with respect to the mechanisms of differentiation. There is no discussion of the fact that some enzymes have been found to be localized in isolated cell wall fractions, or of the suggestive cytological observations which have shown that cell wall synthesis occasionally occurs in regions distinctly remote from the bulk of the cytoplasm.

The overall impression left by Brown's article is one of diffuse organization. A great deal of miscellaneous information has been included, some of it representing trivial background, some of it hopelessly over-simplified, and some of it almost irrelevant to the aims of the series. Those parts which are important as a background for the physiology of plant cells are in many instances inadequately developed. It would seem that a sufficiently strong sense of direction was not impressed on the material, and only occasional sections will prove at all valuable.

A. T. JAGENDORF

PLANT PHYSIOLOGY. *A Treatise. Volume II: Plants in Relation to Water and Solutes. Edited by F. C. Steward. Academic Press, New York and London.* $22.00. xviii + 758 pp.; ill. 1959.

This is the first-published volume of a series for which at least six are intended. The present, very substantial book contains the following chapters: Cell membranes: their resistance to penetration and their capacity for transport (R. Collander); Water relations of cells (T. A. Bennet-Clark); The water relations of stomatal cells and the mechanisms of stomatal movement (O. V. S. Heath); Plants in relation to inorganic salts (F. C. Steward and J. F. Sutcliffe); Translocation of organic solutes (C. A. Swanson); Translocation of inorganic solutes (O. Biddulph); and Transpiration and the water economy of plants (P. J. Kramer).

TRACE ELEMENTS IN PLANTS. *Third Edition. By Walter Stiles. Cambridge University Press, New York and London.* $7.50. xvi + 249 pp. + 16 pl. 1961.

Trace Elements in Plants is the third edition of a book which previously included "animals" in the title. The material has been brought up to date and a new section is included on toxicity due to excess minerals and on availability of the elements depending on soil conditions. In this treatment iron is not considered as a trace element.

The book can be classified as a conscientious re-

counting of trace element problems in plant biology. The emphasis is heavily on the practical and descriptive side; out of the 199 text pages only 36 are given to research on the mechanism of action of the trace elements, whereas 56 pages altogether are used to describe deficiency or toxicity symptoms and to relate these to commonly observed field diseases. In an excellent summarizing statement, Stiles points out the areas for future work, most prominent among which is the site of action of the trace elements.

A portion of the book which represents a waste of space is that containing the excessively detailed descriptions of methods of trace element analysis, both historical and current. These are not sufficiently detailed to permit using them as a practical guide in the laboratory; on the other hand, they are much too detailed for a general reader or even for the critical evaluation of conclusions quoted from the literature. A simple statement of the general principles of analysis would be much more appropriate here.

There are a number of unfortunate omissions in the chapter on function of micronutrients. These include: the very elegant experimental procedures of Pirson studying the kinetics of recovery from a deficiency condition when the mineral is added back; the specific function and site of action of manganese in photosynthesis as found by Gaffron, Kessler, and associates; and the work of Warburg on the function of vanadium in photosynthesis.

Some sections of the book would be much more easily understood with the aid of brief summaries. This is especially true of the parts dealing with complexities of ion interactions during active uptake from the soil solution. As it stands, it is difficult to come to any over-all impression from the series of consecutive facts listed by Stiles. Also the distinction between short-term interactions and long-term indirect effects generally has not been pointed out.

In spite of these drawbacks the book serves as a useful guide to the present status of a field with continuing research interest. An extensive bibliography and an index are included.

A. T. JAGENDORF

ECONOMIC BOTANY

THE RELATION OF FUNGI TO HUMAN AFFAIRS. *By William D. Gray. Henry Holt and Company, New York.* $8.50. xvi + 510 pp.; ill. 1959.

Essentially a textbook of industrial mycology, the book also contains much of general interest. Among the activities of fungi that are discussed are: humus formation, mycorrhizae, industrial fermentation methods, fungi as food, medical uses of fungi and their products, industrial syntheses by fungi, plant disease, destruction of foods and materials, and medical mycology.

THE GRASS COVER OF AFRICA. *FAO Agricultural Studies. No. 49.*

By J. M. Rattray. Food and Agricultural Organization of the United Nations, Rome; Columbia University Press, New York. $2.50 (paper). vi + 168 pp. 1960.

The period since 1955 has seen the emergence in Africa of a large number of countries to independence. This, however, is not a fact of mere political significance. The governmental services of these ex-colonial countries had been carried out by officials trained in a variety of European countries with a variety of approaches to their several disciplines. Particularly in the realm of agricultural, ecological, and phytogeographical studies this has resulted, at best, in different approaches to the same problems, and at worst, a complete lack of uniformity and understanding between workers in similar fields, often in adjacent parts of the Continent. It is perhaps not without significance, therefore, that since 1955 three detailed vegetation maps of Africa have appeared. Before this only one was available.

In 1923 H. L. Shantz published his vegetation map of Africa. For more than 30 years, this was to remain the only vegetation map available. In 1956 a meeting was convened at Yangambi, by the Commission for Scientific Co-operation in Africa South of the Sahara and the Council for Africa South of the Sahara, at which plant geographers met to try to standardize vegetational terms. Out of this meeting, in 1959, a *Vegetational Map of Africa South of the Tropic of Cancer* appeared, on the scale of 1:10,000,000, published by Oxford University Press on behalf of l'Association pour l'Étude Taxonomique de la Flore d'Afrique Tropicale with the assistance of UNESCO. In the same year *Agriculture and Ecology in Africa*, by John Phillips, was published, containing a map of "major bioclimatic regions, based on potential or actual vegetation, on rainfall, humidity and temperature." The map is on a scale of 1:20,000,000 and is concerned with Africa south of the Sahara.

The third vegetation map of Africa to appear recently, *The Grass Cover of Africa*, deals with the whole of the Continent. It is on a scale of 1:10,000,000 and so can be conveniently compared with the AETFAT map. There are 54 major divisions, made mainly on a floristic basis, and each characterized by a particular grass genus, and these are represented on the map by a combination of colors and overprinting. Subdivisions are made on a geographical basis and are given a combination of letters and numbers. In each case the type of vegetation with

which each division is associated is stated. The main vegetation types decided upon at the Yangambi meeting have been used, and these at least have the advantage of establishing some uniformity, although the use of terms of originally local significance like "steppe" (which then has to be qualified to "warm steppe") will be criticized by many ecologists. Why not just "semi-desert scrub"?

The result can best be illustrated by specific examples. In the so-called "Sudan Zone" of vegetation, which stretches from west to east Africa, the grass cover is mostly composed of *Cenchrus* types. These types are designated "*Cenchrus* associated with Savanna" on the map and are subdivided into:—

CE.4 SUDAN.

Cenchrus biflorus—C. ciliaris—Eragrostis tremula—Aristida spp.

CE.5 CENTRAL AFRICAN REPUBLIC, REPUBLIC OF THE CONGO, GABON REPUBLIC, REPUBLIC OF CHAD.

Cenchrus biflorus—Eragrostis tremula—Andropogon pseudapricus—Panicum subalbidum.

CE.6 NIGERIA.

Cenchrus biflorus—Eragrostis tremula—Pennisetum pedicellatum—Diectomis fastigiata—Ctenium elegans—Aristida longiflora—Andropogon gayanus.

CE.7 SUDANESE REPUBLIC.

Cenchrus biflorus—Chloris prieurii—Ctenium elegans—Eragrostis tremula—E. pilosa—Aristida adscensionis—A. mutabilis—A. longiflora—A. stipoides—Perotis patens—Latipes senegalensis—Tragus racemosus—Brachiaria hagerupii—B. deflexa—Trichoneura mollis—Pennisetum pedicellatum—Dactyloctenium aegyptium.

Other *Cenchrus* types, in Southern Rhodesia, Uganda, Ethiopia, and Madagascar, are colored similarly to the above on the map but with different shading, as in these cases the species is associated with steppe.

The book accompanying the map provides adequate descriptions of the habitats of each type, including information on the soil, rainfall, grazing regimes, and associated species. There are also useful chapters on the Ecological Relationships of the Grass Cover and on Successional Changes, as well as an extensive Bibliography.

This map, together with the AETFAT vegetation map and H. Walter's *Klimadiagramm-Karte von Afrika* constitutes an eloquent ecological essay. Even if it does not provide those concerned with agricultural policy in Africa with a more reliable foundation on which to base their calculations, as the author suggests it might, it at least restates the problems in such a way that future work can be both better coordinated and of a more general application throughout the Continent.

M. J. CHADWICK

ENCICLOPEDIA ARGENTINA DE AGRICULTURA Y JARDINERÍA. *Description de las Plantas Cultivadas. Volume 1.*

Edited by L. R. Parodi. Editorial Acme S. A. C. I., Buenos Aires. $28.50. xvl + 931 pp.; ill. 1959.

One of the paradoxes of contemporary botany is that manuals usable to identify wild plants are legion but manuals devoted to cultivated plants—those plants with which man is most directly concerned—are few indeed. Bailey's *Manual of Cultivated Plants*, covering the United States and Canada, has long been the only New World manual dealing with both woody and herbaceous members of a cultivated flora. It has now lost its unique position because of a most worthy rival, the first volume of the *Enciclopedia Argentina de Agricultura y Jardinería*. This volume, which might best be characterized as a "South American Bailey," consists mainly of keys to and descriptions of the cultivated plants of Argentina. The concluding volume will contain sections on Argentina phytogeography, soils, and climate; plant diseases and pests; and cultivation of various domesticated plants. The *Enciclopedia* is edited by the distinguished botanist Ing. Agr. L. R. Parodi, Professor de Botánica Agrícola at the University of Buenos Aires.

Argentina, which has an area about one-third that of the United States, lies mostly in the south temperate zone, but its far north is in the tropical zone. The country extends 2,295 miles from north to south. It has the highest mountain in the Americas and about 1,650 miles of coastline. Obviously it shows great variation in climate and in native and cultivated floras.

Cultivated plants have received considerable attention in Argentina during recent years. At irregular intervals since 1950 the Instituto de Botánica Agrícola has been publishing a series entitled *Las Plantas Cultivadas en la República Argentina*, now numbering 29 issues, each devoted to one family. Articles on various groups of cultivated plants have appeared also in the *Revista de Investigaciones Agrícolas* and the *Revista Argentina de Agronomía*.

Volume 1 of the *Enciclopedia* consists of five chapters, which follow a brief introduction and a detailed table of contents. Chapter 1, by L. R. Parodi, is a discussion of plant classification, nomenclature, and the use of botanical keys. Chapter 2, also by Parodi, summarizes and characterizes the divisions of the plant kingdom and presents an exposition of floral structure, inflorescences, and fruits. Chapter 3 is a key, prepared by Parodi, to the families of vascular plants in the cultivated flora of Argentina.

Chapter 4, by far the longest (817 pages) in the volume, contains descriptions of 183 families, 1,212 genera, and 2,780 species of plants. (Bailey's *Manual* includes 194 families, 1,523 genera, and 5,347 species.) Keys are given to genera and species. Families are arranged according to the Englerian system. Some 600 species are illustrated by line drawings in 248 text figures, of which 108 are full-page in size. The drawings, by Sr. Higinio Lona, are beautifully executed and, for the most part, well reproduced. Ing. Agr. Parodi prepared the text for the Gramineae (79 pages), Melastomaceae (⅓ page), and Martyliaceae (2 pages); Ing. Agr. J. La Porte, for the Cruciferae (15 pages); Ing. Agr. A. Burkart, for the Leguminosae (70 pages); and Dra. M. Correa, for the Orchidaceae (19 pages). The remainder of the chapter (177 families, 632 pages) is the work of Ing. Agr. M. J. Dimitri, whose contributions constitute about two-thirds of the entire text of the volume. Dimitri is Director de Protección de la Naturaleza de la Dirreción General de Parques Nacionales, Buenos Aires. Chapter 5, by Ing. Agr. C. A. Costa de Olivieri, is a 20-page glossary of the principal terms used. Following it, a bibliography and a 9,200 entry index to scientific and common names bring the book to a close. The volume is attractively though not sturdily bound and is printed on paper that is perhaps not so high in quality as such a significant book deserves.

Volume 1 of the *Enciclopedia* is a major contribution to the descriptive literature on cultivated plants. Its general usefulness in the United States will be limited more by language than by difference in domesticated floras. Botanical, horticultural, agricultural, and biological libraries, however, can ill afford not to add the volume to their holdings, if they can afford to buy it at the dissuasively high price of $28.50.

JOHN W. THIERET

DICTIONARY OF ECONOMIC PLANTS.

By. J. C. Th. Uphof. H. R. Engelmann (J. Cramer), Weinheim; [Hafner Publishing Co., New York]. $9.75. viii + 400 pp. 1959.

In this reference work over 6000 different species are listed, with brief characterizations of their distributions and economic uses. Common names in profusion are also listed with identification of the species to which they refer. A bibliography arranged by economic groups of plants and by geographical regions of the world completes the volume.

GENERAL AND SYSTEMATIC ZOOLOGY

PRINCIPLES OF ANIMAL TAXONOMY. *No. XX of the Columbia Biological Series.*

By George Gaylord Simpson. Columbia University Press, New York. $6.00. xiv + 247 pp.; ill. 1961.

A new book by Simpson is sure of a welcome for both its subject-matter and its clarity of exposition; this one tries to fill a long-felt want by discussing the *principles* of taxonomy: we have had much excellent precept recently but nothing on what principles underlie such concepts as groups, classes, natural classification, and so on. Simpson's chapters deal with systematics, taxonomy, classification, and nomenclature; the development of modern taxonomy (a very welcome attempt but unavoidably too brief); taxonomic evidence and evolutionary interpretation; conversion of a taxonomic arrangement into a classification; the species and lower categories; and higher categories. The most cogent comment on it is implicit in Simpson's own statement, "Principles derived from and applicable to mammals are sufficiently general for all Metazoa that the word 'animal' in the title should not constitute false advertising, but a specialist in, say, coelenterates may quite properly reach some other conclusions in the light of his different experience." In a book with this title, however, we need some indication of what different conclusions apply in other groups, and how far the experiences of a (good) mammalian phylogenist are generally applicable. Two serious limitations are evident. First, Simpson rightly points out that taxonomy is one of the ways in which we order our experience, and has therefore a high intrinsic interest for all scientists (and others). But no attempt is made to compare the arrangement of organisms with that of other entities so as to bring out the special features of taxonomy. Dobzhansky has praised Simpson's tolerance in discussing some recent attempts to explore the basis of classification "which fail to see any difference between classification of organisms and classification of, say, postage stamps, although he (Simpson) points out that these attempts have not said anything new or suggested any new line of investigation." But there are things in common in the ordering of postage-stamps and of organisms, as well as outstanding differences. That neither Simpson nor Dobzhansky should see that there could be any point in studying the features common to all arrangements of multi-charactered entities by entity not by characters, suggests that they may have missed the significance or novelty of what has been said. That this is so is indicated by the second limitation, namely that taxonomic arrangement is conceived of as wholly phylogenetic. In consequence, the efforts of those who have tried to clarify what is done in grouping organisms together by affinity or overall similarity, what relation this has to a phylogenetic classification, and (most important) when a phylogenetic classification

is possible at all, are dismissed as "shallow" with no reasons or criteria of depth given. This sort of bias is only too common in taxonomy. The bacteriologist or flowering-plant taxonomist will deny the importance of geographical speciation (for example) or the possibility of phylogenetic classification, while the vertebrate phylogenist or ornithologist will retort angrily to this unjustified condemnation of their life-work. In some groups, good phylogenetic arrangement is possible, and is the basis of the most generally useful classification; in some, it is wholly unjustified, and maybe a continual source of nonsensical name-changing. But within these limitations, as an authoritative account of phylogenetic taxonomy, Simpson's book is certain to be of great use to all taxonomists, and to students of evolution generally.

A. J. CAIN

Малый практикум по зоологии беспозвоночных. Простейшие—Protozoa и бесхордовые многоклеточные—Metazoa achordata.

By S. V. Averintsev (С. В. Аверинцев) *Sovyetskaya nauka*, Moscow. 13 rubles 50 kop. 304 pp., 188 figs. [15,000 copies]. 1947.

Зоология беспозвоночных.

By S. V. Averintsev. Sovyetskaya Nauka, Moscow. 13 rubles, 60 kop. 464 pp., 343 figs. [25,000 copies]. 1952.

Основы сравнительной анатомии беспозвоночных. Изд. второе.

By V. N. Beklemishev (В. Н. Беклемишев). *Sovyetskaya Nauka, Moscow.* 20 rubles, 25 kop., 698 pp., 339 figs. [10,000 copies]. 1952.

Зоология беспозвоночных. Изд. третье.

By V. A. Dogiel (В. А. Догель). *Uchpedgiz, Leningrad.* 10 rubles 30 kop. 479 pp., 6 col. pl., 527 figs. [10,000 copies]. 1939.

Промысловые водные беспозвоночные.

By A. V. Ivanov (А. В. Иванов). *Sovyetskaya Nauka, Moscow.* 8 rubles, 50 kop. 355 pp., 149 figs. [1,200 copies]. 1955.

Беспозвоночные животные (Строение в связи с условиями жизни и значение их для человека).

Edited by L. K. Lozina-Lozinsky (Л. К. Лозина-Лозинский). *Izd. Akad. Pedagog. Nauk, Moscow.* 10 rubles, 55 kop. 406 pp., text figs. [8,000 copies]. 1955.

Зоология беспозвоночных.

By V. F. Natali (В. Ф. Натали) *Uchpedgiz, Moscow*, 13 rubles, 50 kop. 536 pp., 8 col. pl., 409 figs. [50,000 copies]. 1951.

It is of some interest, in the context of the current furor about the training of scientists in Russia as compared with the United States, to examine textbooks in such a relatively non-political field as invertebrate zoology. The Russians are obviously ahead in quantity, as measured by numbers of one-volume survey textbooks, their size (it must be remembered that most of these books, except the *Small Practicum of Invertebrate Zoology* and *Economic Aquatic Invertebrates*, are printed in the long octavo size which accommodates several lines more per page than a book like Parker and Haswell), number of illustrations, and size of editions. There is no great difference in scope between the texts of invertebrate zoology by Averintsev, Dogiel, and Natali, on the one hand, and the familiar Borradaile and Potts or Vol I of Parker and Haswell, on the other. Indeed, they are all very much alike, with the same familiar illustrations culled from "standard sources," and the American student would feel very much at home with these books. Whether he would also complain that they are rather dull reading cannot be said. One has to study a text "for blood," so to speak, before finding out how it wears. Dogiel's text seems to have been one of the more popular ones; a fourth edition appeared in 1949. It differs from the other two mentioned in acknowledging sources of illustrations (hardly necessary for many of them), and in lacking a political preface. The illustrations are also leavened a bit with a few classics from the incunabula of zoology, including Leeuwenhoek and Albrecht Dürer, and Russian works are more heavily drawn upon. Beklemishev's *Outlines of Comparative Invertebrate Anatomy* is something different, a scholarly, detailed research or reference text. It is organized in two parts, the first (to p. 366) a systematic treatment in phylogenetic order, the second a discussion of organ systems ("organology"). There are a few startling innovations in classification: the Arachnida are suppressed in favor of two superorders, Actinochaeta and Actinoderma, and the phoronids and bryozoa (but not the brachiopods) are lumped under the Phylum Actinotrochozoa. On the whole, the classification is better than Dogiel's lumping of all the nondescripts under Vermes. But then Beklemishev is a specialist in the Turbellaria (he dismisses the Mesozoa as incertae sedis), while Dogiel is a protozoologist. The Protostomia-Deuterostomia scheme seems to be firmly established among Russian zoologists (with echinoderms placed after the lower chordates, however), and the trend toward splitting the oddities into separate phyla just as prevalent as among zoologists in this country. Splitting of higher categories is to the advantage of the general biologist, who finds such categories as Vermes and Gephyrea in tables and summaries misleading if not frustrating. Averintsev's *Small Practicum* is essentially a laboratory manual, prefaced by sections on the use of the microscope and microtechnique. Each chapter concludes with a brief annotated bibliography, including references in German, French, and English. None of the others so far mentioned have

bibliographies; this would seem a serious omission in such an advanced text as Beklemishev's.

Among this collection of textbooks there is nothing equivalent to Carter's *General Zoology of the Invertebrates*, although the symposium volume edited by Lozina-Lozinsky may serve somewhat the same purpose. It is organized on an ecological rather than functional basis, however. After an introductory chapter of generalities, there is a chapter on microscopic life, followed by chapters on the invertebrates of the sea, of freshwater, soil, and air, and a concluding chapter on parasitic and pathologic invertebrates. Each chapter has a short annotated bibliography. It is difficult to imagine what sort of course might be organized around such a book, and perhaps none is. The remaining volume, Ivanov's *Commercial Aquatic Invertebrates*, is obviously appropriate for fisheries students. It is devoted for the most part to crustaceans and molluscs, with discussions of their anatomy, biology, methods of capture, etc. Species exotic to Russia, such as pearl oysters, cameo shells, and coconut crabs, are included. The book has an 8-page terminal bibliography.

The books published after 1951 (except Beklemishev) are on good paper, which shows off the line cuts to better advantage, especially in Averinstev's *Invertebrate Zoology*. None of them falls below the quality of Borradaile and Potts, which while acceptable, is not up to the better German and French printing. Even the best of paper, however, can do nothing for half-tones that look as if they had been processed through a dirty mosquito net. The Cyrillic alphabet still awaits its Caslon or Jenson, however, and it is only at its best on the best of paper. The color plates provided in two of the volumes are a mingled assortment of rather gaudy representations of coral reefs and sea-bottom scenes (some of the same plates, in one fuzzier than in the other, adorn both books), and really first-rate plates of insects. Such color printing might be better used for some well-conceived diagrams instead of the all-too-typical textbook monstrosities bristling like pincushions with lines to numbers and letters that must in turn be deciphered from a massive phalanx of small type at the bottom of the page. This typographical crime is no Russian peculiarity, and it is about time that something was done about it. At any rate, it may console some persons to realize that the Russians pay no more attention than we do to the design and printing of textbooks.

The prices stamped on the bindings bear no relation to the prices asked by various dealers in Russian books. For example, one item priced at 8 rubles 50 kopeks was listed at $5.00 by one dealer, while another asked about $2.50 for a book the list price of which was 20 rubles 25 kopeks.

In short, it would appear that zoology students in the Soviet Union (according to an article by D. R. Newth, in *Science News* 40, there are 650 students of zoology alone at Moscow University) are no worse off than ours, and in fact perhaps a bit better off, in their selection of textbooks. Certainly they are looking at the same familiar pictures that have graced zoologies since the days of Delage and Hérouard, Claus, Lang, and other familiar figures.

JOEL W. HEDGPETH

THE LITTORAL FAUNA OF THE BRITISH ISLES. *A Handbook for Collectors. Third Edition.*

By N. B. Eales; foreword by the late Stanley Kemp. Cambridge University Press, New York and London. $6.50. xx + 306 pp. + 25 pl.; text ill. 1961.

This is substantially the same volume as its predecessors, although the title has been changed from *Great Britain* to *British Isles*. Changes have been made in the sections on mysids, tunicates, and polychaetes, and the book is printed on somewhat less bulky paper.

A REVISION OF THE MITES OF THE FAMILY SPINTURNICIDAE (ACARINA). *Univ. Calif. Publ. Entomol., Vol. 17, No. 2.*

By Albert Rudnick. University of California Press, Berkeley and Los Angeles. $2.50 (paper). iv + pp. 157–250 + pl. 18–48. 1960.

Many groups of animals have developed parasitic lines that live exclusively on bats. Many of these chiropteran parasites are quite distinct from the parasitic or free-living organisms from which they arose. The acarine family Spinturnicidae is a fine example of such a group. In this revision of the group, emphasis has been placed on nomenclature, classification, description, distribution, and biology of the 37 included species.

As with most parasitic forms that are readily seen on their hosts, many names have been proposed for the common species. In this particular family confusion was so great that Opinion 128 of the International Commission of Nomenclature outlawed the use of *vespertilionis* as a specific name in combination with the then recognized genera of the family. The application of names in this revision has been accomplished with much care and work, so that it will serve as a base from which future workers can begin with confidence.

The 37 described species are placed in 7 genera, of which 3 are new: *Eyndhovenia*, *Paraperiglischrus*, and *Paraspinturnix*. All of these are monotypic. The wisdom of recognizing these new genera is questionable. The author has merely recognized 3 aberrant species that would fit into previously established genera if the generic diagnoses were broadened. The tendency to consider genera as spectra of morphological patterns as defined by the "generic charac-

ters" rather than as groups of more or less closely related species of animals is not valid.

Included in the revision are lists of hosts, records of collections, and the locations of the type specimens when possible. The illustrations of the mites used to supplement verbal descriptions are excellent. The life cycles appear to be uniform within the group and the stages are: intrauterine egg and larva, protonymph, deutonymph, male and female. Sexual dimorphism is apparent at the deutonymphal stage, so that two types of deutonymphs can be recognized.

This revision is an essential reference for all who wish to study the family. It will also be helpful to those interested in bats, parasites, or mites.

G. W. WHARTON

PSEUDOSCORPIONS FROM COLORADO. *Am. Museum Nat. Hist., Vol. 122, Art. 5.*

By C. Clayton Hoff. American Museum of Natural History, New York. $1.00 (paper). iv + pp. 413–464; ill. 1961.

THE ACROMETOPAE OF THE ETHIOPIAN REGION: A REVISION, WITH NOTES ON THE SEXUAL DIMORPHISM SHOWN BY THE GROUP (ORTHOPTERA: TETTIGONIIDAE). *Brit. Museum Entomol., Vol. 8, No. 7.*

By D. R. Ragge. The British Museum (Natural History), London. 20s. (paper). ii + pp. 269–333; ill. 1960.

CLASSIFICATION OF THE ARADIDAE (HEMIPTERA-HETEROPTERA).

By Robert L. Usinger and Ryuichi Matsuda. British Museum (Natural History), London. £4. viii + 410 pp.; ill. 1959.

The Aradidae are true bugs, commonly known as flat bugs, which eat fungi and live under the bark of dead trees. The first species was described by Linnaeus in 1746. Robert Usinger, during a sabbatical year spent at the British Museum, has now completed, with the aid of R. Matsuda, a superb monograph of the family, even though the senior author apologizes for its lack of completeness and refers to the more than 100 undescribed species in his own collection. The discovery of apterous forms in 1936, by N. C. E. Miller, has led to almost a doubling of the number of genera in the family, since many forms previously regarded by students of the group as nymphs are now seen to comprise new groups.

The introductory material includes a discussion of the morphology of the aradids, their biology, and their distribution. The group is worldwide, dates back at least to the Oligocene, and is represented in the fossil record by 8 species belonging to 3 genera. New Zealand "stands as a natural storehouse of Aradid types unequalled by any other island or continent." A total of 123 genera and 767 species are described, many of both categories being new. Diagrams are clear, and the full-page line drawings of whole insects, done by Arthur Smith of the British Museum, are magnificent examples of scientific artistry. This work will obviously be indispensable to all students of the Hemiptera.

WESTERN BUTTERFLIES.

By Arthur C. Smith; illustrated by Gene M. Christman. Lane Book Company, Menlo Park, Calif. $2.95. 66 pp.; ill. 1961.

The author has succeeded in putting a wealth of scientific information into this one slender, attractive volume. There are 84 colored and 51 black and white drawings of butterflies. The print is very readable and the book can be used by children in the intermediate grades.

Some of the excellent features of this book are the following: (1) the arrangement of the species by habitats; (2) a brief description of the structure of a butterfly, with clearly labeled diagrams; (3) a section describing the stages of development of a butterfly; (4) a section describing how butterflies can be collected, preserved, and studied with home-made equipment, and also listing addresses where professional equipment may be obtained; and (5) a chart of 127 butterflies mentioned in the text, giving their scientific names, common names, range, flight season, larval food plant, and page references.

Because of the excellent general information contained in the book and the fact that some butterflies occur throughout the United States, this book would be a valuable addition to any library in this country.

MARY DEMEREC

A CATALOGUE OF THE TYPES AND OTHER SPECIMENS IN THE BRITISH MUSEUM (NATURAL HISTORY) OF THE GENUS *ZYGAENA* FABRICIUS, LEPIDOPTERA: ZYGAENIDAE. *Bull. Brit. Museum Entomol., Vol. 10, No. 7.*

By W. G. Tremewan. The British Museum (Natural History), London. 40s. (paper). ii + pp. 241–313 + pl. 50–64. 1961.

COLÉOPTÈRES CARABIQUES DU MAROC. *Troisième Partie. Mém. soc. sci. nat. phys. Maroc. Zool., Nouvelle sér., No. 6.*

By Maurice Antoine. Société des Sciences Naturelles et Physiques du Maroc, Rabat. (paper). iv + pp. 315–465; ill. 1959.

This volume deals with the taxonomy of the Family Harpalidae (traditionally Tribe Harpalini, family Carabidae). The harpaline fauna of Morocco comprises 4 subfamilies, 7 tribes, 23 genera and 102 species, including two new species, *Carterus debilis* and *Bradycellus otini*.

For each species the following are provided: synonymy; a brief description; data on habits, habitats, and geographical distribution. Identification is facilitated by a series of keys to the taxa of each category. The male genitalia, including the armature of the internal sac, and other structures useful in identification, are illustrated.

In a consideration of the taxonomic significance of structure of the male genitalia, Antoine points out that in the Harpalidae, while differences in armature are useful for distinguishing among similar species, similarities between otherwise markedly different species do not necessarily mean close relationship.

Harpaline beetles are a challenge to students interested in supraspecific categories. The pattern of character distribution is complex: the same derivative characters seem to have originated independently in various stocks; some groups which are obviously derivative have retained a few primitive features; and some basically primitive groups have a few highly derivative features. Antoine has attempted to take these difficulties into account, in terms of the Moroccan fauna, and has presented a useful classification, which probably comes very close to consistency with phylogenetic relationships.

It is unfortunate that the splitting of the family Carabidae into numerous families by elevation of tribes, first advocated by Jeannel, should have gained such wide currency among coleopterists, especially among the French and Japanese workers. Although it may seem to carabid specialists that their groups of genera are extraordinarily distinct, such groups are really recognized by rather minor characteristics, and these distinguishing characteristics are not absolutely constant.

Since Morocco borders on the Palaearctic and Ethiopian Regions, it is of some interest from a zoogeographical point of view to compare the faunas of these three areas, using the fauna of France to represent the Palaearctic Region. The faunal affinity between Morocco and France as indicated by the number of shared harpaline genera is much closer than is the faunal affinity between Morocco and the Ethiopian Region, and this fact lends support to including the Mediterranean strip of Africa in the Palaearctic Region.

Because this paper contains much valuable information on classification, it is of considerable importance to all students of carabid taxonomy, and must be thoroughly understood by anyone wishing to advance further our knowledge of the harpalines.

G. E. Ball

COLÉOPTÈRES CARABIQUES DU MAROC. *Quatrième Partie. Mém. soc. sci. nat. phys. Maroc., Nouvelle sér., No. 8.*

By Maurice Antoine. Société des Sciences Naturelles et Physiques du Maroc, Rabat. 8.00 NF. (paper). iv + pp. 467–537; ill. 1961.

BEITRÄGE ZUR NEOTROPISCHEN FAUNA. *Band I, Heft 4.*

Edited by Erich Titschack and Hans-Wilhelm Koepcke. Veb Gustav Fischer Verlag, Jena. DM 11.50 (paper). Pp. 269–388. 1959.

This number completes Volume I of the *Beiträge zur neotropischen Fauna* with a lengthy monographic treatment of the Bolivian Alticidae (Halticidae), a phytophagous coleopteran family. There is no summary. By a quick count no less than 14 new genera and 234 new species are described by the author, Jan Bechyné. Evidently the South American beetles are a rich hunting ground for species namers.

BEITRÄGE ZUR NEOTROPISCHEN FAUNA. *Band II, Heft 1.*

Edited by Erich Titschack and Hans-Wilhelm Koepcke. Veb Gustav Fischer Verlag, Jena. 11.45 DM (paper). 64 pp.; ill. 1960.

BEITRÄGE ZUR NEOTROPISCHEN FAUNA. *Band II, Heft 2.*

Edited by Erich Titschack and Hans-Wilhelm Koepcke. Veb Gustav Fischer Verlag, Jena. 7.55 DM (paper). pp. 65–141; ill. 1960.

These two pamphlet contributions to the description of the Neotropical fauna respectively concern chiefly the polychaetes of Peru (Gesa Hartmann-Schröder) and the neotropical Staphylinidae, order Coleoptera (Otto Scheerpeltz). In Heft 1 there is also a brief contribution on the South American Agrioninae (order Odonata), by Douglas St. Quentin. One new species is described. The study devoted to the polychaetes presents ecological data with reference to their relation to the Humboldt current. One new genus and 16 new species are described. Heft 2: The monographic treatment of the staphylinid beetles of the neotropics unfortunately lacks a summary, but by a quick count there are 28 new species, of which no less than 14 have been given the trivial cognomen "Forsteri" (sic), thus immortalizing the fortunate collector. What confusion this practice in nomenclature is likely to introduce into the taxonomy, whenever revisers see reason to shift these beetles from one genus to another, can readily be imagined. Perhaps the phenomenon is to be taken as warning that Scheerpeltz wants no one tampering with his perfectly ordered arrangement! This number also contains a brief note on the validity of the South American colubrid snake species, *Leptophis cupreus* Cope.

Bentley Glass

A Revision of the Ecuadorian Snakes of the Colubrid Genus *Atractus*. *Misc. Publ. Museum Zool. Univ. Mich, No. 112.*

By Jay M. Savage. Museum of Zoology, University of Michigan, Ann Arbor. $2.00 (paper). 86 pp.; ill. 1960.

The Mammals of El Salvador. *Misc. Publ. Museum Zool. Univ. Mich., No. 117.*

By William Henry Burt and Reuben A. Stirton. Museum of Zoology, University of Michigan, Ann Arbor. $1.60 (paper). 69 pp.; ill. 1961.

A Review of the Bats of Trinidad and Tobago. *Descriptions, Rabies Infection, and Ecology. Bull. Am. Mus. Nat. Hist., Vol. 122, Art. 3.*

By George G. Goodwin and Arthur M. Greenhall. American Museum of Natural History, New York. $4.00 (paper). ii + pp. 191–301 + pl. 7–46; text ill. 1961.

The vast number and amazing variety of bats on the island of Trinidad has been known and recognized since the earliest days of discovery. The finding of rabies virus in vampires in 1925 initiated the modern period of intensive bat study on the island. The present publication is the result of joint efforts by the American Museum of Natural History and the various agencies in Trinidad interested in the epidemiology of bat-borne diseases and their impact upon both the human and animal populations of the island.

Most of the book is devoted to a systematic account of the species. No less than 61 species and subspecies are known, of which only 3 are known from Tobago and not Trinidad. Identification keys are provided, and in addition to the usual systematic and nomenclatural information, there is for each form a brief résumé of its habits. There are numerous pen and ink drawings of salient taxonomic characters, and a considerable series of plates, some showing bats in their natural habitat, and many illustrating the skulls of the various species.

There is a good description of the physiography and climate of the islands, and a comprehensive review of the history and development of bat studies in this area. In all, this is a very scholarly and comprehensive review of the bat fauna of this important area.

Bryan P. Glass

ECONOMIC ZOOLOGY

The Biology of the Fleece. *Animal Research Laboratories Technical Paper No. 3.*

By A. S. Fraser and B. F. Short. Commonwealth Scientific and Industrial Research Organization, Melbourne. Free upon request. 108 pp. + 5 pl.; text ill. 1960.

This rather unusual monograph will be of interest to embryologists concerned with the development and growth of hair in mammals, to geneticists, and of course to animal breeders. It contains an appendix on the dominant and recessive *N* genes of New Zealand Romney sheep. (S. K. Stephenson and A. S. Fraser). This is a locus with pleiotropic effects not only on the development of hair follicles and nature of the hair fiber, but on prenatal and postnatal body growth in general, development of the horns, and various other effects. A second appendix gives a histological technique for the study of the skin follicle population in sheep (W. H. Clarke).

ANIMAL GROWTH AND DEVELOPMENT

Animal Growth and Development. *Foundations of Modern Biology Series.*

By Maurice Sussman. Prentice-Hall, Englewood Cliffs. $1.50 (paper). xiv + 114 pp.; ill. 1960.

This volume is one of a series of short monographs, each by a distinguished investigator in his field, intended to replace the more conventional single volume general biology text. By the use of compact self-contained (and presumably disposable) units the authors hope to achieve a more timely and more flexible introduction to the biological sciences.

Whether this purpose is served is obviously beyond the scope of this review. One shortcoming which may mitigate against its use in lieu of a conventional text is the absence, in this volume at least, of specific page and volume references to background information presumably covered in other volumes of the series and which the reader is, from time to time, encouraged to "recall."

This deficiency notwithstanding, Sussman's monograph could serve admirably to supplement either a general biology or general embryology text. Its cardinal strength is that it presents developmental biology to the beginning student as a growing experimental science rather than merely an overwhelming catalogue of desiccated description and seemingly endless glossary. The catalogue is, in fact, present in highly condensed form (Chapter 5) and can be referred to as needed. Elsewhere in the volume what descriptive information is needed to understand the experimental principles under discussion is given concurrently. This arrangement is both more logical as well as more palatable.

The manner in which the reader is led successively through the statement of a problem, the experimental approaches to its solution, and the discussion of the conclusions drawn, is far more effective an explanation of the mechanisms of scientific investiga-

tion than any formal discussion of "the scientific method" could have been. A keener appreciation of the dynamic character of biological science is conveyed by indicating the next logical steps to be taken and by pointing out the areas which are relatively unexplored.

Generally one can find little to quarrel with in the conclusions which the author draws from the experimental data which he uses. One notable exception is the evidence cited for "direct-contact induction" (p. 85). The author's conclusion, in this case, is a full one hundred and eighty degrees from the usual interpretation of the data to which he alludes.

A great variety of animal forms are used as examples of specific developmental phenomena. Although it is well to establish, for the student, the universality of developmental principles, there is the concomitant risk of obscuring the forest.

In general, the written style is extremely lucid, interesting and even, on occasion, amusing. What a great pity, however, that Sussman's students will forever be cheated of the opportunity of speculating on whether the professor writes his jokes into his lecture notes—he does!

I. KONIGSBERG

ANIMAL MORPHOLOGY

DIGESTIVE PHYSIOLOGY AND NUTRITION OF THE RUMINANT. *Proceedings of the University of Nottingham Seventh Easter School in Agricultural Science, 1960. Edited by D. Lewis. Butterworths, London.* $9.50. x + 297 pp.; ill. 1961.

Sometime during the process of evolution there emerged two groups of animals, one with highly developed digestive systems and the other with highly developed brains. The former group of animals is able to thrive on almost anything because these animals possess an expanded anterior portion of the stomach, the rumen, which contains large numbers of microorganisms capable of converting a wide variety of dietary constituents into nutritious products. The latter group of animals grows poorly on grass, but thrives on investigating almost anything, and periodically holds conferences where large numbers of publications are reviewed and converted into condensed, readable products. One such conference was held in April, 1960, at the University of Nottingham School of Agriculture. This volume is the product: it contains 23 papers covering studies by about 700 investigators, complete with discussions, subject index, and author index.

The editor appropriately summarized the presentations in this volume, as follows: "Activities within the rumen are no longer a mystery to the biologist and the chemist: the micro-organisms present have been largely identified, counted, isolated and their properties examined; overall metabolic pathways within the rumen are relatively well understood; the organ itself has been thoroughly studied, its innervation, blood supply and the factors governing its movements; in fact, as can be seen from the proceedings of this conference the rumen itself as an entity in its own right has been thoroughly examined and the detail of its activities largely known." This infers that our knowledge of the rumen is almost complete. Does the ruminologist have little left to study? On the last page of the text the final discussant answers this question: "I realize that I have asked a lot of questions and I should be surprised if there were anyone here with the answers to them; what we have heard in this conference, however, may help us to answer them for ourselves."

This excellent volume contains many answers for the biologist, animal husbandman, nutritionist, physiologist, biochemist, microbiologist, and endocrinologist. On the other hand, there are more answers to be obtained: the book could just as well serve as an appropriate starting point for departure into further studies of the ruminant.

PAUL A. HARTMAN

THE CATERPILLAR AND THE BUTTERFLY. *Smithsonian Misc. Collections, Vol. 143, No. 6. Publ. 4472. By R. E. Snodgrass. Smithsonian Institution, Washington.* Seventy-five cents (paper). iv + 51 pp.; ill. 1961.

ANIMAL PHYSIOLOGY

COMPARATIVE ANIMAL PHYSIOLOGY. *Second Edition. By C. Ladd Prosser and Frank A. Brown, Jr. W. B. Saunders Company, Philadelphia and London.* $15.50. x + 688 pp.; ill. 1961.

It is a pleasure to note the appearance of a revised edition of this indispensable book. While the text has been thoroughly rewritten and brought up to date, its scope and style have been changed scarcely at all. Consequently, its audience and its usefulness are as before. The work reviews the comparative physiology of animals from the protozoa to the mammals.

The contents are arranged according to function: Water; osmotic balance; Inorganic ions; Nutrition; Feeding and digestion; Nitrogen excretion; Respiration and metabolism; Respiratory functions of body fluids; Temperature; Mechanoreception, equilibrium reception, and phonoreception; Chemoreception; Photoreception; Circulation of body fluids; Muscle and electric organs; Amoeboid movement; Cilia; Trichocysts and nematocysts; Bioluminescence;

Chromatophores; Endocrine mechanisms; and Nervous systems.

The material is wholly revised and includes references to work published as recently as 1960. Many of the illustrations also are new. The typography, the quality of paper and binding, and the illustrations are very much better than those of the first edition, a happy change. The style of writing is extremely compact, as it must be to consider so much. In the rewriting, somewhat more attention has been given to providing explanations, summaries, and conclusions; in many sections a decided improvement is evident.

The authors' intent, that this book should serve as a textbook in advanced courses, is again not adequately fulfilled. While the contents of each chapter are usually technically sound or even admirably selected and written, the material in many cases is almost useless to anyone who is not already very well informed on the subject. There is simply not space enough in which to elaborate sufficiently for the material to stand on its own, given the enormous scope of the subject. The authors probably feel that the advantages of the comparative approach overshadow such considerations and that designing the treatise for "advanced" courses overcomes the difficulty. It seems preferable to emphasize that the book is useful primarily as an excellent reference work and as a good place to begin a literature search in an area of invertebrate physiology.

DAVID R. EVANS

THE PHYSIOLOGY OF CRUSTACEA. *Sense Organs, Integration, and Behavior. Volume II.*

Edited by Talbot H. Waterman. Academic Press, New York and London. $23.00. xiv + 681 pp.; ill. 1961.

The second and last volume of this series lives up to expectations (*Quart. Rev. Biol.*, 35: 242. 1960); it is a definitive review of the subject. Its contents and authors are: Light sensitivity and vision (Waterman); Mechanoreception (M. J. Cohen and Sven Dijkgraaf); Chemoreception and thermoreception (S. B. Barber); Pigmentary effectors (L. H. Kleinholz); Light production (E. N. Harvey); The neuromuscular system (C. A. G. Wiersma); Reflexes and the central nervous system (Wiersma); Neurohumors and neurosecretion (J. H. Welsh); Locomotion (J. H. Lochhead); Kinetic and tactic responses (L. Pardi and F. Pardi); Physiological rhythms (F. A. Brown, Jr.); Migrations (R. Bainbridge); Complex behavior (H. Schöne); and Comparative physiology (Waterman). The last chapter is a sort of summary in which the material is organized about the theme of comparative physiology. Waterman outlines in a sophisticated way the role of the comparative approach, its philosophical basis, and its applicability at all levels of organization.

Again there has been meticulous care to integrate the several sections of the volume, to provide abundant explanations and summaries, and to supply thorough indices to subject, to author, and to taxonomic group. The intent of the editor apparently was to produce an exhaustive treatment of the highest quality, and he has certainly succeeded. An only reservation concerns that intent: need the product have been so lavish ($45 for the pair)? The aim for comprehensiveness has led to the inclusion of much that possibly has only remote physiological value. To those familiar with arthropod physiology, to note that *Insect Physiology* (Roeder; 1953), while of similar format, had some 200 fewer pages than do these two volumes indicates the inclusiveness of the present books. Otherwise there is no doubt as to their lasting value.

DAVID R. EVANS

SENSORY COMMUNICATION. *Contributions to the Symposium on Principles of Sensory Communication. July 19–August 1, 1959, Endicott House, M. I. T.*

Edited by Walter A. Rosenblith. The M. I. T. Press, Cambridge; John Wiley & Sons, New York and London. $16.00. xvi + 844 pp.; ill. 1961.

Although this book appears in print two years after the symposium on which it reports was held, the papers and discussions in it are surprisingly up to date. Several of the references are to papers which appeared after the symposium, a fact indicating that much of the delay in publication may have been due to the problem of getting the authors to send their papers to the editor. There are 38 formal papers, several of which are accompanied by critiques from the other members of the symposium. All parts of the sensory system are considered, from the initial organization of the stimulus upon the receptor organ to the final decoding of the sensory information by the central nervous system. As might be expected, most of the papers are concerned with the intermediate parts of this process. Although most of the papers are conceived as critical reviews, many of them contain original work and some even contain original ideas. One article must be singled out because it contains work that is otherwise not readily accessible. This is the paper by the late Hl. de Vries and M. Struiver on the absolute sensitivity of the human sense of smell. The authors, using a Poisson statistical method analogous to that used for quantum thresholds in vision, show that less than 40 molecules of a substance can produce a sensation and that one molecule may be enough to stimulate a single olfactory receptor.

The discussions that follow the papers are quite interesting. In many of them some of the aspects of lateral inhibition (a new bandwagon for neurophysiologists) are developed in more detail than is

usual. The book will repay careful study for its new ideas, and can also be used as a reference book for a clear exposition of older ideas.

MYRON L. WOLBARSHT

CYCLICAL ACTIVITY IN ENDOCRINE SYSTEMS. *Proceedings of a Symposium held at The Zoological Society of London, Regent's Park, London, N. W. 1 on 8th December, 1959. Number 2.*

Edited by E. J. W. Barrington. The Zoological Society of London, London. £1 5s. 0d. (paper). x + 120 pp. + 2 pl.; text ill. 1960.

Contents: Thyroid cycles in fish (A. J. Matty); Cyclical activity of the thyroid of fish in relation to environmental changes (D. R. Swift); Internal and external factors in the regulation of the spermatogenetic cycle in amphibia (P. G. W. J. van Oordt); The environment, cyclical reproductive activity, and behaviour in birds (A. J. Marshall); Optic glands and the ovary of *Octopus* (M. J. Wells); Moulting cycles in Crustacea (D. B. Carlisle); and Some problems of adenohypophysial relationships in cyclostomes and fish (E. J. W. Barrington).

CIBA FOUNDATION SYMPOSIUM ON CELLULAR ASPECTS OF IMMUNITY.

Edited by G. E. W. Wolstenholme and Maeve O'Connor. Little, Brown and Company, Boston. $10.50. xii + 495 pp.; ill. 1960.

This volume is composed of papers presented at the Ciba Foundation Symposium held in the Abbey of Royaumont, near Paris, June 3–5, 1959. All of the published material is in English, with the exception of the Chairman's closing remarks in French. Fortunately for the reader, and in line with current published symposia, the discussions following the papers are included and they proved enlightening and informative.

Since several of the authors rely heavily on cytological data, it should be noted that the quality and reproduction of photomicrographs is quite good.

The volume includes the following contributions: Nomenclature of immunologically competent cells (Astrid Fagraeus); An in vitro study of some mechanisms of antigen uptake by cells (R. Robineaux and Janine Pinet); Degradation of a protein antigen by intracellular enzymes (C. Lapresle and T. Webb); Microcinematographic contributions to the study of plasma cells (J. P. Thiéry); Ultrastructure of immunologically competent cells (W. Bernhard and N. Granboulan); Identification of immunologically competent cells (M. Simonsen); Theories of immunological tolerance (P. B. Medawar); Panel discussion on the clonal selection theory of antibody formation (Burnet, Lederberg); Lymph node cell transfer in relation to antibody formation (T. N. Harris and Susanna Harris); Formation of antibodies in vitro (P. Grabar and P. Corvazier); A study of serum proteins related to immunity and their cellular origins (P. Buttin); The cellular basis for the immunological memory (D. W. Dresser and N. A. Mitchison); Some biological and immunological properties of transfer factor (H. Sherwood Lawrence); A comparative histopathological study of delayed hypersensitive reactions (B. H. Waksman); Interactions between sessile and humoral antibodies in homograft reactions (P. A. Gorer); Response to active immunization of human infants during the neonatal period (R. T. Smith); Modifications of capillary permeability in immunological reactions mediated through cells (G. A. Voisin and Francine Toullet); The patterns and mechanism of fixation of anaphylactic antibody on living tissues in vitro (B. N. Halpern, P. Liacopoulos, R. Binaghi, and R. Liacopoulos-Briot); Multiple "autoantibodies" to cell constituents in systemic lupus erythematosus (H. G. Kunkel, H. R. Holman, and H. R. G. Deicher); The in vitro action of antigen-antibody complexes on thrombocytes and erythrocytes (P. Mieschet, N. S. Cooper, and D. Hurez); and Group discussion in summary (Burnet, with Dixon, Fagraeus, Good, Grabar, Susanna Harris, Humphrey, Kunkel, Lederberg, Medawar, Miles, Monod, Simonsen, Waksman, Smith, and Sterzl).

The scientific quality of the papers, as well as the care taken by the editors and publishers in preparing the volume, provided the reviewer with an enjoyable assignment. The book should be an asset to a "working" bookshelf for people in this immediate area of research, and should also serve to whet the appetite of those who would like to learn more about a fascinating area of biology.

S. R. SUSKIND

MECHANISMS OF ANTIBODY FORMATION. *Proceedings of a Symposium held in Prague, May 27–31, 1959.*

Edited by M. Holub and L. Jarošková. Academic Press, New York and London; Publishing House of the Czechoslovak Academy of Sciences, Prague. $10.00. 385 pp.; ill. 1961.

To Jaroslav Sterzl, Head of the Immunological Division, Institute of Biology, Czechoslovak Academy of Sciences, we owe a debt of gratitude for initiating the symposium from which this excellent publication springs. The Editors, Holub and Jarošková, also are to be congratulated for collating some 40 articles and important contributions effectively. Six principal topics are treated: (1) Cells engaged in antibody production; (2) The fate of antigen and the importance of different routes of administration; (3) The inductive phase of antibody formation; (4) The productive phase of antibody formation; (5) Secondary and nonspecific anamnestic responses; and (6) Methods of

depressing and enhancing antibody production. The quality of the articles is surprisingly even—almost uniformly good to excellent. Today, more than two years after their presentation, most of them are fresh and readable, for the symposium was held at a time when new facts were appearing rapidly and ideas were being generated. Many of the hypotheses advanced still have not been tested fully. The book will enable the reader to gain perspective on the origin and development of many of the current arguments in immunobiology. I have found it a valuable addition to my own library.

J. D. Ebert

Ciba Foundation Symposium on Haemopoiesis. *Cell Production and its Regulation.*

Edited by G. E. W. Wolstenholme and Maeve O'Connor. Little, Brown and Company, Boston. $11.00. xii + 490 pp.; ill. 1960.

This symposium brought together a group of investigators who are advancing knowledge concerning proliferation of hematopoietic cells and the mechanism of its control. A transcript of the proceedings provides a valuable summary of available information and current concepts pertaining to this rapidly developing field. Emphasis is placed on quantitative aspects of cell production as studied by new techniques, in particular the use of tritiated thymidine. Of particular significance is the inclusion of the informal discussions which took place between the participants; for here one discovers not only points of disagreement, but also possible explanations for some of the conflicts, including limitations of methods. The leukocytes are the subject of most of the considerations of cell proliferation and the lymphocytes receive special attention. Discussion of the control of hematopoiesis is centered principally about the regulation of erythropoiesis. The symposium reflects the extraordinary advances which have resulted from recent dynamic studies of the hematopoietic system, an area in which morphologic observation was the chief source of information only a few years ago. The individual chapters are adequately referenced. The book provides an excellent summary of latest information in a fundamental area of biology.

C. Lockard Conley

Lipoids and Blood Platelets. *With Reference to Blood Coagulation and the Hemorrhagic Diseases. By John H. Ferguson. The University of North Carolina Press, Chapel Hill.* $5.00 (paper). xx + 278 pp.; ill. 1960.

The author, who has devoted many years of his life to the study of blood clotting, summarizes information concerning the role of blood platelets in coagulation. A short historical review is followed by a brief and uncritical compilation of information concerning the functions and constituents of platelets. A long and heterogeneous series of experiments and clinical observations is recorded, each in the form of an experimental protocol followed by a brief discussion. This method of presentation is difficult to follow, and even the conclusions are confusing. The formulation is that of the classic coagulationist, the platelet being considered as a structure housing a long list of "factors." No mention is made of the significant recent studies of other investigators who have established that the platelet is a living cell, the biologic functions of which are to a considerable extent dependent on its metabolic activity.

C. Lockard Conley

BIOPHYSICS AND GENERAL PHYSIOLOGY

Chemical Ultrastructure in Living Tissues. *American Lecture Series.*

By J. B. Finean. Charles C Thomas, Springfield, Ill. $6.00. xii + 131 pp.; ill. 1961.

As our techniques take us deeper into the structure of the cell, there is an increased need to consider organization and function in molecular terms. This means, in essence, an excursion into the dynamics of macromolecular chemistry, a trip not to be undertaken lightly if one has in mind contributions to basic and original knowledge. The techniques involved are sufficiently diverse and complicated—those of the biochemist, crystallographer, geneticist, etc.—to scare off the faint-hearted, but fortunately an appreciation of the field in terms of its emerging unity and its potential value to biology and medicine is made easier by the fine handling of the subject matter by authors such as Finean.

This small volume consists of only 3 chapters dealing with methods, chemistry, and structure, but the result is an excellent review of a rapidly moving, open-ended science, written especially for the clinician who will be expected to encounter anomalies in his practice and who will want to know what is going on in chemistry and biology that will elucidate and possibly solve some of his problems. Books such as this should find a wider use than they are likely to receive in this hurried world.

C. P. Swanson

Macromolecular Complexes. *The Society of General Physiologists Sixth Annual Symposium, University of Illinois, Urbana, Illinois, September 1959.*

Edited by M. V. Edds, Jr. The Ronald Press Company, New York. $7.00. vi + 257 pp.; ill. 1961.

The tools of the modern cell biologist have been

focussed to a very large extent on the macromolecules that govern function and contribute heavily to cellular organization. Although much of the cell remains in solution, biologists are more than ever conscious of the fact that little happens in the cell that is haphazard, and that uniqueness on the one hand and orderliness on the other arise hierarchically from lower to higher levels because of macromolecular aggregates. The question arises then, as the editor points out, "Is the spontaneous emergence of order at a higher level inevitable?" assuming that the proper units and conditions exist at the immediately preceding lower level.

An affirmative answer can be given to the above question, partly because of the knowledge of specific interactions of molecular systems and partly because, intuitively, there is no other answer as satisfying. With this question in mind, each of the speakers has dealt with some aspect of molecular aggregation and the consequences of this action: D. F. Waugh with short and long range forces; A. J. Hodge and F. O. Schmidt on collagen; M. J. Glimcher on collagen in calcification; J. J. Wolken on the chloroplast; H. Fernández-Morán on lamellar systems in myelin and photoreceptors; H. A. Went and D. Mazia on the mitotic apparatus; J. A. Bergeron and R. C. Fuller on bacterial structure in relation to photosynthesis; W. J. Nickerson, E. Falcone and G. Kessler on yeast cell walls with their polysaccharide-protein complexes; and R. D. Preston on cellulose-protein aggregates in plant cell walls.

Each of the papers is highly technical and well-documented; they do not make for easy reading. Yet running through each is the theme that as life arises from life, so order arises from previous order, with macromolecules providing the prerequisite shape, size, and reactivity necessary to an hierarchically progression that leads to definitive form and function recognizable as the differentiated organelle, a cell, or an organism.

C. P. Swanson

Annual Review of Nuclear Science. *Volume 10. Edited by Emilio Segrè; assoc. eds. Gerhart Friedlander and Walter E. Meyerhoff. Annual Reviews, Palo Alto.* $7.00. viii + 617 pp.; ill. 1960.

During the nine years of their existence the *Annual Reviews of Nuclear Science* have become an indispensable part of the physicist's education and probably the chief means of his keeping up-to-date in his own subject. The very high standard of the review articles, their thoroughness, and comprehensiveness, have earned the publication great respect and gratitude. Perhaps one of the most attractive features of the *Reviews* is that the term *nuclear science* is interpreted in a very broad sense. Every volume contains surveys of subjects only remotely associated with nuclear physics. Radiobiology appears to be a particular favourite of the editors; every issue contains several articles dealing with the effects of radiations on biological systems. To a certain extent this is probably connected with the well-known interest of nuclear physicists in molecular biology; it may also be a somewhat arrogant expression of the physicist's belief that they are at the helm of radiobiology. But whatever the reason, the *Reviews of Nuclear Science* have become known among radiobiologists as an admirable way of keeping pace with the progress in their subject. As usual, they are excellent value for money.

In the volume under review, there are 3 articles on radiobiology: on cellular radiobiology (Tikvah Alper); on the metabolism of internal emitters (Roy C. Thompson); and on late effects of radiation (J. B. Storer and D. Grahn). In previous volumes the same, or nearly the same, topics were surveyed, and the present articles are, therefore, largely based on very recent data. It is an attestation of the extremely rapid growth of radiobiology that there is so much new material to review every year.

The article by Miss Alper is extremely authoritative and informative and, at the same time, fair, and balanced. The subject matter is so arranged that the reader gets an overall picture of the role played by the various physical and chemical parameters on different types of biological material. Thus, for example, there is a thorough discussion on dose-effect relationships, and on the effects of radiations of different qualities. A large chapter is devoted to the modification of radiation response by treatment before, during, and after irradiation. The very important oxygen-effect—to the understanding of which the author has herself contributed a great deal—is discussed under this heading. Recent biochemical investigations are also reviewed. The survey ends with some speculations on the mechanism of radiobiological action. The long list of references, containing 224 items, adds to the completeness of the survey.

The review by Thompson brings the subject much nearer to nuclear physics than to biology. It deals with the metabolism of radioactive isotopes, which may be contained in the human body, from the point of view of radiation hazards, although the actual damage caused by these substances is not discussed. After some general considerations about methods of detection, routes of entry into the body, and the retention of radioactive isotopes, the problems relating to specific radio-nuclides are analysed in detail. In particular, the metabolism of isotopes from fall-out, such as strontium-90 and cesium-137, are of general interest. Once again, there is a very long list of references which makes it easier for the

interested reader to follow any specific item in greater detail.

The last article, by Storer and Grahn, is fairly short and deals with the late effects of radiation: life-shortening, leukaemogenesis, and genetics. The style is very lively, which makes for interesting reading, and it is clear that the authors are thoroughly familiar with the subject; perhaps the only fault one can find with it is that the authors allow their personal views to come to the fore too often. One sometimes wonders whether a survey article should in fact be written by people who are actively engaged in research in the branch of science under review, and who may, therefore, have some axe to grind.

J. ROTBLAT

THE DELAYED EFFECTS OF WHOLE-BODY RADIATION: *A Symposium. Jointly sponsored by the Operations Research Office and the Walter Reed Army Institute of Research.*

Edited by Bernard B. Watson. Operations Research Office, Johns Hopkins Press, Baltimore. $4.50. x + 80 pp.; ill. 1960.

The hazard to man from ionizing radiations is, for obvious reasons, a very much discussed subject. There has probably been more written, debated, and argued about this than on any other topic in recent times, but most of this is either speculative extrapolation or a re-digestion of what other people have said. The amount of factual material is extremely small and the acquisition of new data very slow. It will take many years before enough experimental evidence is accumulated to make possible the direct determination of the magnitude of the radiation hazard to man. In the meantime, the assessment must inevitably fall back on data obtained with experimental animals. The book under review is no exception in this respect.

The purpose of the symposium was purely utilitarian: to obtain information about the magnitude of damage likely to be suffered by the officers and men of the U. S. Army, in view of the fact that "... with the continuing threat of radiation exposure imposed by nuclear weapons and the associated battlefield contamination, the soldier of the future is likely to experience radiation exposures above those now considered permissible for occupationally exposed personnel" (quote from foreword). The symposium was divided into 4 groups, each dealing with one of the long-term effects of radiation: life-shortening, induction of neoplasms, induction of cataracts, and genetic damage. In each of these groups 2 papers were given, one connected with animal experiments and the other with information relating to man, but the most accurate and reliable data were naturally those obtained from animal work.

The papers are a mixed bag: a few are based on original work of the authors, but most papers contain surveys of the work of others. From this point of view a paper given at such a symposium falls between two stools: it does not present all the details of technique and the basic information which one usually finds in an original publication, nor is it broad enough to give an overall picture of the whole subject which one obtains from a review article. The main advantage of a symposium arises from the discussion on the papers, when new ideas may emerge from a free exchange of views. In this particular symposium the discussion was rather flat. It is a pity that a verbatim record is given, for it could have been improved with some editing and deleting of trivialities. In the papers, too, there seems to be some repetition, which goes well with the spoken word but is unnecessary in writing: a little bit of editing might have improved matters.

The reproduction of the book itself is faultless.

J. ROTBLAT

BIOCHEMISTRY

FORMATION AND TRAPPING OF FREE RADICALS.

Edited by Arnold M. Bass and H. P. Broida. Academic Press, New York and London. $16.00 xvi + 522 pp.; ill. 1960.

The availability of electron spin resonance equipment has led to a renewal of interest in the study of free radicals, especially in biological systems. The chemistry of free radicals as transient intermediates has been covered quite well in the literature, especially from the standpoint of reaction kinetics and product analysis. A different approach to free radical chemistry is outlined by Bass and Broida in this volume dealing with the handling of free radicals as discrete substances. The isolation of free radicals permits a close examination, by various physical tools, of these reactive and elusive intermediates.

The present volume is essentially a report on the present state of the art of free radical trapping. All aspects of the isolation approach are covered: design of equipment, generation of radicals, trapping of radicals in a matrix, and identification of the radicals (each section is well documented with references). In addition to these subjects, the history of radical trapping is reviewed by F. O. Rice and progress (up to 1959) on the trapping of radicals of common interest is given. Of special interest to *Quarterly Review* readers will be the two chapters—Trapped Radicals in Radiation Damage and Trapped Radicals in Biological Processes.

EMIL H. WHITE

BIOLOGICAL DEGRADATION OF CELLULOSE. *Organic Chemistry Monographs.*

By J. A. Gascoigne and Margaret M. Gascoigne. Butterworths, London, Toronto, Sydney, Wellington, and Durban. $8.00. vi + 264 pp.; ill. 1960.

This book offers the reader a bird's eye view of the fundamental and applied aspects of enzymatic cellulose decomposition. Two chapters serve to introduce the chemistry of cellulose and associated compounds, and the specificity of enzyme action, with special reference to enzymes involved in reactions of β-linked glycosides. The next chapter consists of a table which lists about 150 species which produce cellulases, together with properties of the enzymes studied, substrates used, observations of note, and appropriate references. Three excellent chapters follow: the purification, properties, and mode of action of the cellulases are enumerated in detail. Information on the hemicellulases is summarized in the next chapter. A final chapter is devoted to the industrial significance of cellulases. In the latter chapter, the role of cellulases in the textile, wood, and paper industries is emphasized, but attention is also given to the prevention of enzyme action, cellulases in animal digestion, saccharification of wastes, and cereal enzymes.

Those with an interest in the biological degradation of cellulose could well use this book as a reference source, if not as a means of reviewing the tremendous quantity of work that has been done in this area. The index may not be entirely adequate for these purposes; however, the material is rather comprehensively covered and has been well organized; entrance to a specific subject in the volume should not be too difficult.

PAUL A. HARTMAN

CHROMATOGRAPHIC AND ELECTROPHORETIC TECHNIQUES. *Volume I: Chromatography. Volume II: Zone Electrophoresis. Second Edition.*

Edited by Ivor Smith. William Heinemann—Medical Books, London; Interscience Publishers, New York. (Vol. I) $10.75; (Vol. II) $5.50. (Vol. I) xviii + 617 pp.; ill.; (Vol. II) viii + 215 pp.; ill. 1960.

In his introduction to the first edition of this work the author stated that "the purpose of this work is, therefore, to bring together in concise form tried and tested methods and techniques (i.e., of chromatography) which have been used by clinical and other biochemists." These goals have been admirably achieved in this second edition as well. These volumes represent a co-operative effort under the editorship of Ivor Smith; the contributing authors were apparently chosen with some care from the ranks of experimenters active in the fields covered.

The introductory chapters contain detailed descriptions of apparatus and routine techniques whereas the later chapters are devoted to the application of these techniques to specific problems. "Reduction to practice" is stressed in these chapters which are well documented with tables of solvent systems and rf values, and photographs of equipment and typical chromatograms. An index of the compounds listed in the various tables is another useful feature. These volumes supplement the related works by Block and Lederer, and they represent a useful addition to the literature of chromatography.

EMIL H. WHITE

ELEMENTARY BIOCHEMISTRY.

By Edwin T. Mertz. Burgess Publishing Company, Minneapolis. $6.50. vi + 298 pp.; ill. 1959.

Printed by photo-offset, this brief book is intended as a survey course for second semester sophomores with a knowledge of general chemistry and elementary organic chemistry.

MICROBIAL CELL WALLS. *CIBA Lectures in Microbial Biochemistry.*

By M. R. J. Salton. John Wiley & Sons, New York and London. $3.50. x + 94 pp.; ill. 1961.

This little book gives a simple and concise introduction to the general properties of the cell walls of bacteria and fungi. Their morphological and physical properties, their chemical constitutions, and their enzymic degradation and biosynthesis are briefly treated in separate chapters. The effects of various antibiotics and inhibitors of cell wall formation are also mentioned. References to the pertinent original literature are quite complete through 1959; a convenient index is included. The presentation is more lucid and clearly written than most other recent reviews of this area, including a number written by the same author. The material selected for presentation, however, accentuates the trend in such treatments to omit from the discussion contributions to the subject arising from immunological studies.

PHILIP E. HARTMAN

PROTEIN BIOSYNTHESIS. *A Symposium held at Wassenaar, 29 August–2 September, 1960 under the auspices of UNESCO and the Council for International Organizations of Medical Sciences.*

Edited by R. J. C. Harris. Academic Press, London and New York. $14.00. xii + 409 pp.; ill. 1961.

Few areas of biochemical investigation have attracted so much interest and imaginative experimentation during the past 5 years as has the study of protein biosynthesis. This volume presents a fairly

broad cross-section of the approaches being used to elucidate the steps and biochemical mechanisms involved in the synthesis of proteins. It contains a number of papers worthy of attention by workers in the field and by those who are following closely each advance in this area. Most of the studies are well-documented and constitute solid reports. Only a few suffer from "symposiumitis," in that they have been concocted especially for the meetings and represent sketchy reviews of previously published data or preliminary studies which have been included without the full editorial review such manuscripts (might) receive elsewhere. Nevertheless, the volume does collect together experimental results obtained with several different systems and includes some discussion of the presentations. In so doing, it presents to the reader a perspective which is more difficult to obtain through perusal of reports otherwise scattered in the literature.

PHILIP E. HARTMAN

HEMOGLOBIN AND ITS ABNORMALITIES. *American Lecture Series. Publ. No. 416.*

By Vernon M. Ingram. Charles C Thomas, Springfield, Ill. $7.50. xiv + 153 pp.; ill. 1961.

The advances made in our understanding of the inheritance, synthesis, and evolutionary-ecological implications of hemoglobin and its variant forms have provided one of the really exciting chapters of modern biology. The elucidation of the underlying biochemistry and genetics of sickle cell anemia, with its attendant hemoglobin S, gained its impetus from clinical studies of hemoglobinopathies, but the intrinsic basic problems now made approachable through electrophoretic and fingerprinting methods inevitably attracted the attention of the whole biological community. Ingram, the author of this volume and a biochemist by trade, has been one of those who has contributed substantially to the field. His immediate contribution in the form of this brief monograph is to be similarly applauded in the sense that it is consistent with the broader responsibilities of a scientist, that, namely, of making the substance and significance of his research intelligible to as broad an audience as is possible. He has given us a readable, concise review of the biology and chemistry of a molecule whose structure and reactivity is precisely and ideally suited to its physiological role, whose variation is a rich mother lode for the chemical geneticist to mine with enthusiasm, and whose clinical involvement is a subject of much human concern.

In approaching his subject, Ingram deals first with the chemistry, architecture, and synthesis of normal hemoglobin. He then considers the abnormal variants, the genetics underlying their inheritance, and the methods used in fingerprinting. Two short chapters are concerned with fetal hemoglobin, and with thalassemia and hemoglobin H. A concluding chapter ties the various threads together, and points out future hopes of filling the obvious gaps in our knowledge. The monograph is clearly to be viewed as a current assessment of the field, and while the author indulges in some speculation, the reader has little difficulty in separating sound fact from educated guess. It is a volume to be commended and recommended.

C. P. SWANSON

EXPOSÉS ANNUELS DE BIOCHEMIE MÉDICALE. *Twentieth Series.*

Edited by P. Boulanger, M.-F. Jayle, and J. Roche. Masson & Cie., Paris. 3,500 fr. (paper). iv + 247 pp.; ill. 1958.

This number of the Exposes Annuels de Biochimie Medicale contains 16 review articles, 10 of which deal with hemoglobin. All of them, even those written by scientists of other countries and languages, are presented in French. The topics considered are as follows: The history of hemoglobin (D. Rittenberg); The molecular structure of the hemoglobin pigments (J. Roche); The metabolism of aminolevulinic acid and the biosynthesis of heme (A. Neuberger); The biogenesis of hemoglobin by the peripheral blood of the rabbit (H. Benard, A. Gajdos, and Mme. Gajdos-Török); New data on a plasma factor stimulating the biosynthesis of hemoglobin in vitro (A. Nizet and C. Rimington); Relations between the formation of heme and globin (I. M. London, J. C. Savoie, and H. Morell); Cellular and molecular renovation: hemoglobin and red cell (G. Schapira, J. C. Dreyfus, and J. Kruh); Fetal hemoglobin (J. H. P. Jonxis); The multiplicity of normal human hemoglobins (Y. Derrien and R. Cabannes); The structure of abnormal hemoglobins (V. M. Ingram); The response of cells in vitro to the addition of chemical factors (H. Lettré); The role of polypeptides in physiology and pathology (K. Felix); Some chemical problems concerning tuberculosis (E. Lederer); The biochemical role of the nucleus of the cell (J. Brachet); Lysosomes (C. de Duve); and Perspective on the specific biochemistry of rheumatoid arthritis (J. Badin). The high reputations of the individual authors guarantee that the reviews will be thought-provoking and present adequately the current status of knowledge on the subjects discussed. The rapid advances now being made in the study of hemoglobin do, of course, quickly make reviews on that subject seem out of date. A volume such as this provides an excellent basis for language study and for seminar discussions on the part of graduate students.

BENTLEY GLASS

PHYSICO-CHIMIE BIOLOGIQUE ET MÉDICALE.

By Christian Bénézech. Masson & Cie., Paris. 8,000 fr. viii + 684 pp.; ill. 1958.

The importance of thermodynamics and of physical chemistry to biological fields such as medicine has led more than one author to attempt an exposition of the sciences for the benefit of present or potential practitioners of the art. A few have been successful in their attempts. The author of the present text is not one of these.

There are 4 major sections to this book. The first deals with classical thermodynamic topics. The second section, indicated as covering homogeneous states of living matter, in fact presents relatively elementary concepts of physical chemistry. The third section extends the concepts to the properties of proteins and of other macromolecules in solutions. The last section purports to deal with the application of content of the earlier chapters to biological systems.

There is relatively little continuity from one section to the next. Some concepts, clearly enough discussed in the first sections, are miserably garbled in the last section, apparently in deference to current usage in certain biological fields. There is inclusion of inappropriate material such as the circuit diagram of an alternating current bridge for conductivity measurements and a full-page table for temperature corrections. This is in sharp contrast to most of the text, which is generally quite didactic and relatively deficient in experimental data. There are some gross errors in all sections but particularly in those in which clinical matters are touched on (for example, the use of ion exchange resins, the carbon-dioxide system in blood, and the mode of action of ammonium chloride).

The author states that he has attempted to bridge the gap between physical chemists and biologists. He has provided a compendium of elementary thermodynamics and physical chemistry that will have its uses as a refresher. But in his major attempt he has unfortunately failed.

FRANCIS P. CHINARD

MICROBIOLOGY

INTRODUCTION TO SOIL MICROBIOLOGY.

By Martin Alexander. John Wiley & Sons, New York and London. $9.50. x + 472 pp.; ill. 1961.

Thirty-five years ago S. A. Waksman appropriately described the needs for the present volume when he wrote the preface to his *Principles of Soil Microbiology* (1927): "An attempt has been made to compile a book which will be of service not only to the investigators in soil science, but also to workers in allied sciences, especially botany, plant physiology, plant pathology and bacteriology, as well as to the general student in agriculture." Waksman filled the stated needs by providing texts in soil microbiology for twenty-five years. A decade has passed, however, since the appearance of his last book, *Soil Microbiology*, (1952) (*Q.R.B.*, 29: 400. 1954). During this time the soil flora and fauna have been under continued and intensified surveillance; numerous discoveries of significance have awaited integration with important contributions of previous decades. Waksman's latest book served well for many years, but now a more recent text is most welcome. The author of the present volume admirably unites old and new knowledge into an understandable and lucid account of soil microbiology.

A chapter on The Soil Environment introduces the first section of the book. Other chapters of this section, Microbial Ecology, deal with the important groups of soil microorganisms: Bacteria, Actinomycetes, Fungi, Algae, Protozoa, and Viruses. Each of these chapters contains a discussion of the distribution and abundance of the microbial group, followed by consideration of the influence of environmental conditions on the presence and activities of the group, and taxonomy, ecology, nutrition and functions of important representatives of the group. These chapters contain a considerable amount of material in clear and concise form; however, the student must consult a number of references listed following each chapter to learn more about soil types, clarify various taxonomical relationships of the organisms presented, and become acquainted with analytical procedures utilized to study soil microorganisms and their activities. The second section covers The Carbon Cycle, while the next two sections survey The Nitrogen Cycle and Mineral Transformations. In these three sections excellent summaries are given of current knowledge regarding microbial interactions with various soil constituents. For each constituent, consideration is given the biological process and its importance in soil fertility and plant growth, chemistry of the transformation, microbiological aspects of the permutation, environmental influences on the process, and biochemical mechanisms. The last section, Ecological Interrelationships, comes almost as an anticlimax, although it contains some of the more fascinating insights regarding the complexities of natural populations. Beneficial and antagonistic associations of soil microorganisms are discussed in one chapter, while a second chapter deals with microflora of the root zone.

No errors of great magnitude could be detected. Rarely is the wording ambiguous, two exceptions being the unitage used in some examples (i.e., p. 317) and definition of the terms "competition" and "amensalism" (p. 426). Several omissions may have been intentional, two examples being lack of information on standardization and testing of seed inocu-

lants, and a negligible discussion of mycorrhiza. The index is adequate, but not exceptional. A chapter entitled Some Aspects of Microbial Physiology serves little purpose and could well have been omitted from the second section. Otherwise, a more succinct account of microbial mediation in soil transformations could not be written without neglecting many important aspects of the subject.

PAUL A. HARTMAN

LABORATORY MANUAL FOR DAIRY MICROBIOLOGY. *Third Edition.*

By E. M. Foster and W. C. Frazier. Burgess Publishing Company, Minneapolis. $3.00 (paper). viii + 72 pp. 1961.

PARASITOLOGY

INTRODUCTION TO PARASITOLOGY. *With Special Reference to the Parasites of Man. 10th Edition.*

By the late Asa C. Chandler and Clark P. Read. John Wiley & Sons, New York and London. $9.75. xii + 822 pp.; ill. 1961.

This first revision undertaken by Read since Chandler's passing continues to be the most readable textbook in parasitology in the English language, since Read has continued, essentially unchanged, the organization that has made the previous editions so useful. He has left Chandler's easily flowing language intact and has shown himself an apt student in blending his changes and additions so smoothly into Chandler's language that they are scarcely detectable.

Without apology or without wasting space in detailing the obvious explanation, Read has removed the long chapter on Spirochaetes which was so conspicuously present in previous editions. In place of this, he has enlarged into a separate chapter the coverage on the Arthropod-Borne Organisms—Other than the Protozoa. However, that title has always troubled this reader. It seems even more inappropriate as a chapter heading in this edition than in previous editions, where it was incorporated as part of a chapter covering one group of the protozoa. It would appear that the arthropod-borne helminth infections would fall under this title. They are, however, logically considered with the other helminths.

This edition, as the past editions, is oriented largely for the undergraduate. However, the broader coverage attempted beyond the parasites of man is conspicuously more sketchy than the coverage of the forms of medical importance. The graduate student, the medical student, and the physician will find useful information in this volume, but the clinical, pathological, and therapeutic coverage is inadequate for a primary text or reference in medical parasitology.

The illustrations are well chosen for the student in biology and are effectively labeled. The edition is remarkably free of typographical and typesetting errors. However, this edition continues an awkward and confusing explanation, for example, in the chapter on the intestinal flagellates, that the "Coccidians . . . will be reserved for consideration . . . along with other Sporozoa." (bottom of page 87; page 112 in the 9th edition).

On the whole this edition, as the previous editions, is well written.

GILBERT F. OTTO

PARASITOLOGIE FÜR ÄRZTE.

By Otto Jírovec. Veb Gustav Fischer, Jena. DM 93.65. xii + 684 pp.; ill. 1960.

The Foreword states that there are several good textbooks on medical parasitology in the German language but that they are concerned largely with tropical medicine and tropical parasitology and consequently have limited applicability for physicians in the temperate climate of central Europe. The present book is an exposition of the course in parasitology presented in the University of Prague. It is directed to medical students and physicians of the region and is concerned with the diseases they are likely to encounter, chiefly infectious by protozoans and other organisms transmitted by arthropods. Primary emphasis is devoted to the bionomics of the parasites and to the diagnosis, therapy, and epidemiology of the diseases caused by them. Clinical features are treated briefly, since fuller information is available in textbooks of internal medicine. Persons interested in tropical medicine and parasitology are referred to the *Lehrbuch der Tropenkrankheiten* by Nauck (1956) and others to the *Lehrbuch der Parasitologie* by Piekarski (1954). Although the text refers to individual researches, the bibliography is limited to textbooks and larger monographs and selected papers by Czechoslovakian authors. The reader is informed that additional literature is available in the textbook by Piekarski.

After a general introductory chapter on parasites, their bionomics, effects, and measures for control, with a section on technical procedures and methods for investigation, the book is divided into three sections that deal respectively with parasitic protozoa (pp. 95–352), parasitic worms (pp. 353–501), and parasitic arthropods (pp. 502–655). The section dealing with the protozoans and related organisms and with the diseases caused by them, considers in order the species in the digestive tract, and those of the genera *Trichomonas, Trypanosoma, Leishmania, Plasmodia, Toxoplasma, Sarcosporidia, Pneumocystis, Spirochaeta, Rickettsia,* and *Bartonella.* The author is an

authority on members of this assemblage and this section is the best part of the book. The chapters on parasitic worms and parasitic arthropods are essentially compilatory, with little critical analysis or evaluation of data. The section on parasitic worms begins with brief taxonomic considerations and discussion of parasites of the vascular system (*Schistosoma* spp.); the lungs (*Paragonimus*); the liver (*Clonorchis, Opisthorchis, Fasciola, Dicrocoelium,* and *Pseudamphistomum*); and of the intestine (*Fasciolopsis, Heterophyes, Metagonimus, Echinostoma, Euparyphium, Himasthla, Watsonius,* and *Gastrodiscus*). The cestodes of man are discussed on the basis of both strobilate and larval stages. Attention is given to sparganosis and cysticercosis. The nematodes parasitic in man receive cursory and curtailed treatment with a list of species, and emphasis on hookworms, *Ascaris, Enterobius, Strongyloides,* and *Trichinella.* The filarial species are listed but receive brief consideration. The section on parasitic arthropods contains discussions of mites, ticks, bugs, and members of the Diptera: flies, fleas, mosquitoes, and midges. Attention is directed primarily to the morphology, life-cycles, bionomics, and medical significance of these arthropods and to the epidemiology of the diseases caused, dispersed, or transmitted by them.

Some of the illustrations are good; others are poor. The book contains many errors, particularly in misspelled words and careless editing, e.g., in discussing schistosome dermatitis (misspelled swimmerscitch), the statement is made that the inflammation is caused by cercariae of different avian nematodes "(Cercarien von verschiedenen Vogelnematoden)" (p. 382). Despite shortcomings, the book is a useful compendium, although it lacks the quality of Brumpt's *Précis de Parasitologie* (*Q.R.B.*, 3: 444. 1927.) or Martini's *Lehrbuch der medizinische Entomologie.*

HORACE W. STUNKARD

TRATADO DE DOENÇAS DAS AVES. *Parte II: Volume III, Doenças Produzidas por Protozoários E Artrópodes Parasitas. Volume IV, Doenças Produzidas por Helmintos, Doenças da Nutrição, Doenças dos Órgãos E Aparelhos, Vícios-Envenenamentos, Patologia do do Desenvolvimento, Higiene-Terapêutica Geral E Cirúrgica.*

By J. Reis and P. Nobrega. Edições Melhoramentos, São Paulo. $15.00. 428 pp.; ill.

Volumes III and IV of this treatise on the diseases of birds are bound together. Volume III treats of the diseases produced by protozoans and parasitic arthropods. Volume IV takes up the diseases attributable to helminths, nutritional deficiencies, perosis, gout, and a treatment of the pathology of organs and organ systems. There is an extensive index. A list of references follows each chapter or section. Only a very few of these are more recent than 1940. The text is in Portuguese.

HEALTH AND DISEASE

ANNUAL REVIEW OF MEDICINE. *Volume 12.*

David A. Rytand, editor; William P. Creger, assoc. ed. Annual Reviews, Palo Alto. $7.00. viii + 455 pp.; ill. 1961.

The high quality of this well-known series is maintained in the latest collection. The contributions are as follows: Infectious disease: respiratory viruses (R. M. Chanock and K. M. Johnson); Physiology of the surgically altered stomach (C. E. Welch and D. S. Ellis); Malabsorption: celiac sprue (C. E. Rubin); Cardiovascular disease: myocardiopathies (E. D. Robin); Cardiovascular disease: extracorporeal circulation (D. G. Melrose); Hormonal influences on renal function (L. G. Wesson, Jr.); Kidney disease: acquired tubular disorders (with special reference to disturbances of concentration and dilution of acid-base regulation) (A. S. Relman and N. G. Levinsky); Untoward reactions to antimicrobial agents (H. G. Simon and L. A. Rantz); Oral hypoglycemic agents (A. Marble); Evaluation of hazards of radiation exposure in medical practice (L. H. Hempelmann); Neoplastic disease: tumor metabolism (H. Busch and J. R. Davis); Neoplastic disease: tumor-virus relations (S. E. Stewart); Hematology: iron metabolism (E. Beutler); Bile pigment metabolism (G. Klatskin); The porphyrins and the porphyrias (L. Eales); Endocrine tissue transplantation (J. R. Brooks); Physiology of the placenta (H. Prystowsky); Dermatology: the eccrine sweat glands (W. C. Lobitz, Jr., and R. L. Dobson); Medical aspects of space flight (A. H. Schwichtenberg); Neural control of endocrine function (G. Farrell and E. W. Rauschkolb); Psychiatry: psychometrics (C. L. Winder); Psychotherapeutic drugs (B. B. Brodie, F. Sulser, and E. Costa); Respiratory problems of the newborn (C. D. Cook); and Evaluation of pulmonary function (E. A. Gaensler).

VICTOR A. MCKUSICK

EXPERIMENTATION IN MAN. *Monograph in American Lectures in Medicine.*

By Henry K. Beecher. Charles C Thomas, Springfield, Ill. $3.50. iv + 80 pp. 1959.

The area of experimentation upon human subjects which is considered in this brief treatise is the physiological and medical. There is considerable discussion of the proper use of the placebo. Genetic, psychological, and various other aspects are not introduced. The background of the discussion is set by the disclosures at the Nuremberg trials of Nazi "ex-

periments" upon persons in their concentration camps. The most valuable part of the booklet consists of the section giving summaries of the codes of behavior governing these matters, especially the Nuremberg Code. Those who refer to this booklet and have not already done so should first read *Doctors of Infamy*, by A. Mitscherlich and F. Mielke.

BENTLEY GLASS

PSYCHOLOGY AND ANIMAL BEHAVIOR

MAN AND DOLPHIN. *Adventures on a New Scientific Frontier.*

By John C. Lilly. Doubleday & Company, Garden City. $4.95. 312 pp.; ill. 1961.

It was the size of the brain in whales that first attracted the attention of the author, a neurophysiologist, to this group of mammals. It was his attempts to map the brain of the dolphin that led him to formulate and test certain theories concerning the possibility of intelligent intercommunication between these animals and man. The present book reviews, in popular language, the progresses of these studies to date. Lilly has been able to induce well-conditioned and seemingly pleasurable responses to stimulation of certain areas of the brain. Further, he has been able to train the dolphins to react so as to initiate the stimulation, and with far fewer trial-and-error contacts than similar experiments require in monkeys. Other experiments revealed that the dolphins communicate with each other, and that this is accomplished mainly by vocalization.

Early experiments indicated that for the sake of both experimenter and subject it would be necessary to establish a study area in a place where the water was nearly 80°F. the year round, and where an open air enclosure could be built, large enough for the subjects to swim in a natural, active manner. Such a station has now been established in St. Thomas, Virgin Islands.

By using tape recordings, Lilly has been able to establish that dolphins do indeed produce a great variety of sounds, and many of these evoke specific responses from other dolphins. To this extent, it seems plausible to refer to this as a language. Whether or not this language can be learned by man is still under investigation. However, Lilly proposes a further step, which really takes one to the very perimeter of present knowledge of animal psychology and behavior: he thinks it may be possible that dolphins will learn to understand human language. In his chapter on "implications" he carries this thought over into the realms of philosophy, ethics, law, utility, and even humor.

The book puts forth in very readable fashion a study that many people have heard about and most have "pooh-pooh-ed," but few have had the chance to read about and evaluate for themselves.

BRYAN P. GLASS

DRUGS AND BEHAVIOR.

Edited by Leonard Uhr and James G. Miller. John Wiley & Sons, New York and London. $10.75. xx + 676 pp.; ill. 1960.

Sixty-three contributors including the editors have written chapters in this book. They have tried, rather unsuccessfully it seems to me, to produce a coherent account of the methodological issues in psychopharmacological research and the major concerns of objectively studying behavior in animals and man as it is modified by drugs. However, theory of drug action in behavior studies is diffuse and embryonic and it is no criticism of the authors that they have been unable to present a clear and unified picture of the subject at this time.

The volume is divided into 2 parts; Part I (10 Chapters) includes the methodological, chemical, biological, and clinical aspects of the subject; Part II (39 Chapters) embraces a description of experimental procedures in animal studies and the assessment of human behavior, normal and pathologic, as modified by drugs. A summary of "objective" behavior measures used in patients was written by Uhr.

It is rather strange that this book, dealing with a major class of drugs, has only two pharmacologists among the 63 authors and they have written only a 2-page summary chapter on the effects of secobarbital, chlorpromazine, meprobamate, and phenaglycodol on subjects in a simulated auto-driving device. This work has been published elsewhere and is of dubious value in predicting the effects of drugs on real-life automobile driving.

Because the psychological jargon is obscure and the contents disjointed, most readers will be attracted to other reviews of this subject.

C. JELLEFF CARR

HUMAN BIOLOGY

PSYCHOPHYSIOLOGICAL ASPECTS OF SPACE FLIGHT. *Symposium sponsored by the School of Aviation Medicine, USAF Aerospace Medical Center, and held late in May, 1960.*

Edited by Bernard E. Flaherty. Columbia University Press, New York. $10.00. xii + 393 pp.; ill. 1961.

Although there are a large number of papers in this collection, many of them are quite short in length. They are grouped into 4 categories. Included under the general heading of Technical Background and Experience are the papers on space vehicle operator

requirements, Project Mercury program and objectives, simulated space flight experiences, and sensory physiological considerations. The second grouping is titled Critical Problems Areas. These papers deal with Astronaut selection and training, stress, circadian rhythms, and physiological data acquisition. Group III carries the general title of Problems of Human Reliability. Here the subject of sensory overloading, sensory deprivation, -isolation, skill maintenance, etc. is included. The last group is a series of 4 papers on Special Techniques of Control and are: one on prolonged hypothermia, one on cybernetics, another on hypnosis as a tool, and a paper titled Conclusion.

With a few exceptions the papers are expressive of the introductory statement by Bernard Flaherty—"Where are we now and where do we go from here?" However, one of the papers, that by Horace Magoun on the Neurophysiology of Stress, though well written and a good treatment of the current physiological concepts of the limbic or visceral brain, is strangely out of place in this assemblage of papers. The paper by Nathan Kline and Manifred Clynes on Drugs, Space and Cybernetics is a curious one. It contains a provision of miscellanea and anecdotes; the thinking is at times imaginative and original; in other passages it is discordant and disconnected.

In such a fast-moving field as space biology, it is inevitable that a certain amount of the speculation resorted to in discussion becomes obsolete before it reaches the bookshelves. It is hard to determine if this text has more value than as a record of the proceedings of this symposium.

HENRY G. WAGNER

BIOMETRY

ANALISI STATISTICA PER MEDICI E BIOLOGI. *E Analisi del Dosaggio Biologico.*

By Luigi Cavalli-Sforza. Editore Boringhieri, Torino. L.2500 (paper). xii + 209 pp.; ill. 1961.

This is a clear and succinct presentation of elementary statistical methods with particular reference to their use in bioassay. The first half of the book is devoted to methods of computing averages, variance, regression, and correlation coefficients. The second half discusses response curves, transformations, some basic experimental designs, and probit analysis. Although the book admittedly leans heavily on Finney's and on Fisher's well-known texts, the author has selected wisely the important concepts which he wishes to illustrate, and, by simple numerical examples, he elucidates these concepts in a manner understandable to investigators with little or no knowledge of theoretical statistics.

ANTONIO CIOCCO

DE OMNIBUS REBUS ET QUIBUSDAM ALIIS

PRATIQUE DU LABORATOIRE. *Techniques Générales—Diagnostics Biologiques—Examens Biochimiques—Expertises Alimentaires—Hématologie—Sériologie—Parasitologie et Entomologie Médicales—Technique Anatomo—Pathologique. Second Edition.*

Edited and Compiled by Ch. Jaulmes, A. Jude, and J. Querangal des Essarts. Masson & Cie, Paris. 7,600 fr. (cloth); 6,500 fr. (paper). vi + 872 pp. + 5 pl.; text ill. 1958.

The principal change embodied in the second edition of this laboratory guide is an increase by 150 pages (first edition, *Q. R. B.*, 29: 427. 1954). It is even more massive and redoubtable than before. Granting that some techniques, such as the Rh blood typing procedures, are now more fully described, I still believe that smaller, more specialized volumes can be of greater usefulness. The water-front is growing longer and broader by the day, and the effort to cover all biological laboratory techniques in a single tome, even of the size of an unabridged dictionary, is clearly in vain. These strictures are pointed not at this present reference work alone, but at all such volumes, of which there are a good many.

BENTLEY GLASS

THE GALÁPAGOS ISLANDS. *A History of Their Exploration. Occasional Papers Calif. Acad. Sci., No. XXV.*

By Joseph Richard Slevin. California Academy of Sciences, San Francisco. $3.50 (paper). x + 150 pp.; ill. 1959.

For persons who are planning a trip to the Galápagos or are interested in the birds and other animals of this remarkable archipelago, and of course for all avid Darwinians, this publication will supply some unusual background reading. Did you know that Darwin visited the islands exactly 300 years after their discovery? Or that there were nine different scientific visits or expeditions to the Galápagos before 1900? It is all here and much more besides.

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